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Contents

Income Distribution of PPP Mode in Transportation Infrastructure Construction

Chang Liu, Xuemeng Guo, and Hongchang Li

Abstract Under the background of the national planning strategy such as "One Belt, One Road" and "Thirteenth Five-Year Plan", China introduced PPP as a financing model and used private capital to ease the government's financial pressure on transportation infrastructure construction. With the support of national supply-side reform and mixed-ownership economy, PPP has already caused a wave of application in China. However, due to the particularity of the PPP model, it is possible to make appropriate arrangements for core stakeholders when establishing a cooperation contract. The distribution of income largely affects the success of the project. Based on the feasibility of the argument, this paper constructs the income distribution model and mechanism, and designs and corrects the PPP model stakeholder the income distribution model based on the Shapley value method. The X urban rail transit project is taken as an example of empirical research. Analyze the influencing factors and correct the income distribution model.

Keywords PPP model · Transportation infrastructure · Stakeholders · Income distribution · Shapley model

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1 Introduction

With the peak of China's railway investment, the demand for transportation equipment has further expanded. The "13th Five-Year Plan" proposes that the state should vigorously promote the new urbanization of the country. The gradual increase of the urban population will expand the scale of existing cities, exacerbate the congestion dilemma, and increase the speed of construction and development of transportation infrastructure. The situation that the big market demand does not match investment and financing.

The traditional financing model is gradually unable to meet the development needs of transportation infrastructure. Because information asymmetry and human barriers will produce problems that bear the risk and the corresponding income distribution does not match. As the country's demand for transportation infrastructure development and investment scale increase, the economies of various regions have been affected to a large extent, and regional governments are facing greater financial pressure. In recent years, the supply-side structural reform strategy proposed by the state has accelerated the application of the PPP investment and financing model in the field of transportation infrastructure construction. The PPP model has become more and more widely used in transportation infrastructure construction projects, but there are few practical implementation cases. The possible reasons are the inefficient allocation of resources caused by the asymmetry of public capital and private capital information, or the external incentives of the transportation infrastructure PPP project. And the constraint mechanism is lacking.

Therefore, the research question of this paper is: How should the projected income under the PPP mode of transportation infrastructure construction be rationally distributed? How is income distribution affected by the behaviour of both public and private parties and the incentive system? What kind of income distribution design can effectively realize the rational allocation of costs, benefits and risks among stakeholders and improve the efficiency of transportation infrastructure PPP mode and regional economic development?

2 Literature Review

In the academic field, researchers focus on the research of PPP models and the mining of related concepts, as well as thinking about solving problems in practical applications [1, 2]. China's research in the field of PPP mode started late, but with the increase in the popularity of the PPP model in China, it has in turn promoted its development in the academic field. The research direction of the PPP model at an early stage focused on the analysis of the popularization and application of related concepts [3–5]. In the field of transportation infrastructure, Lei [6] focused on the whole life cycle of the transportation infrastructure construction PPP project and discussed the key points of the optimization of the transportation infrastructure government and the social capital cooperation system.

In the research on income distribution of the infrastructure PPP mode, some scholars have conducted game analysis on the public sector and the private sector in the PPP mode from three aspects: cooperation structure, core competitiveness and balance of interests of related parties, combining the social attributes and the economy of the two departments. Introduced a relatively effective, fair and reasonable project income allocation program [7]. In the field of transportation infrastructure, Viegas [8] analyzes the relevant factors in the project that may affect the income distribution plan, such as contract duration, transaction costs, the attitudes of all parties, and in-depth discussion of the stakes involved in the PPP model. The problem of income distribution. In China's research, based on the analysis of key influencing factors, there are game theory models [9], Nash model [10], Shapley model [11], or based on risk sharing [12, 13] to conduct research on income distribution. In the study of transportation infrastructure, some scholars have used the Shapley model to analyze the interests of the three stakeholders of state-owned investment companies, private companies and relocated residents and construct a revenue distribution method [14]. In more in-depth research, some scholars have considered the impact of excess return distribution on the level of investor effort. By taking into account the horizontal and vertical fairness preferences of investors, the principal-agent model for constructing the optimal distribution of excess returns of PPP transportation projects [15].

At present, the imperfect problem of PPP mode exists in the problem of not being able to solve the problem of income distribution of relevant participants. No matter in the theoretical field or the field of practical application, there is not much research on this aspect, and the PPP mode for specific fields, For example, in the field of transportation infrastructure, there are fewer related studies on the distribution of income.

3 Construction of the Income Distribution Model Based on Shapley Value

3.1 Model Design Ideas

The PPP model is a "full process" partnership between the government and social capital to build infrastructure projects and provide public services. It is of great significance to alleviate the pressure on government fiscal expenditures and reduce the burden on the government. The basic characteristics of the transportation infrastructure PPP model include the diversification of the participants' needs, the shared revenue sharing risks, and the quasi-public product and special economic characteristics. Choosing the Shapley value method to measure the income distribution plan for core participants in the PPP model of transportation infrastructure construction can avoid simple average distribution defects and enable the public and private sectors to take positive decision-making behaviors in the construction of transportation infrastructure. Conducive to the implementation of the overall project construction and operation.

However, the basic Shapley value method cannot take into account the other influencing factors in the traffic infrastructure PPP model and the fluctuations caused by the incentive measures of all parties. The balance of the overall cooperation model and the promotion of positive measures among the participants are The lack of it is not conducive to the creation of the overall project revenue, and the direct application of the underlying income distribution model is not sufficient and comprehensive. Therefore, the basic model is adjusted, the influence of influencing factors is analyzed, and the factor correction model is added to improve the scientific defects of the basic model, to establish a fair and objective way to establish a PPP model income distribution model that encourages participants to take active measures.

3.2 Shapley Value Method Foundation Model Establishment

Assume that $I = \{1, 2, \ldots n\}$ is a set of n stakeholders in the PPP mode. For any subset of I, $S \in I$, there is a corresponding function $V(S)$, which satisfies:

$$V(\varphi) = 0 \tag{1}$$

$$V(S_1 \cup S_2) \geq V(S_1) + V(S_2),\ S_1 \cap S_2 = \varphi \tag{2}$$

$[I, V]$ is defined as a game with n stakeholders, and V is the corresponding special diagnosis function mentioned above. This article is the income of the construction project.

Use Y_i to represent the maximum income distribution value that the i-th stakeholder in the set I can obtain from the construction project income, so the income of the construction project that the different stakeholders in the set I can allocate with the vector $Y = (Y_1, Y_2, \ldots, Y_n)$, and the establishment of the income distribution model needs to meet the individual rationality of the participants as well as the overall rational requirements.

Overall rationality:

$$\sum\nolimits_{i=1}^{n} Y_i = V(I) \qquad i = 1, 2, \ldots n \tag{3}$$

Individual rationality:

$$Y_i \geq V(i) \qquad i = 1, 2, \ldots n \tag{4}$$

$V(i)$ represents the income that stakeholders i can create if they are solely responsible for project construction. $V(I)$ represents the maximum benefit that can be created in the case of many cooperation possibilities. The Shapley value of the overall revenue of the project, defined as $Y_i(V)$:

$$Y_i(V) = \sum\nolimits_{S_i \in S} W(|S|)[V(S) - V(S \backslash i)] \qquad i = 1, 2, \ldots n \tag{5}$$

$$W(|S|) = ((n - |S|)!(|S| - 1)!)/n! \tag{6}$$

S represents the case of all cooperation modes including individual factors, stakeholders i, in the set I, $|S|$ is the number of stakeholders in cooperation mode S, and $W(|S|)$ represents a weighting factor. $V(S)$ represents the income of the construction project that can be created by the model S, and $V(S\backslash i)$ represents the project income that can be created if the cooperation model S does not include the stakeholder i.

It is assumed that according to the cooperation mode formed by random conditions, the probability of occurrence of each mode is equivalent, that is, $1/n!$. Stakeholder i forms an overall cooperation model S with other $|S| - 1$ stakeholders, so the marginal contribution of stakeholder i to the overall project benefit is defined as $V(S) - V(S\backslash i)$. There are a total of $(n - |S|)!(|S| - 1)!$ types of $S\backslash i$ and $N\backslash S$ stakeholders randomly sorted. The probability of occurrence in each case is $((n - |S|)!(|S| - 1)!)/n!$. At this time, the marginal contribution expected value created by stakeholder i is the assigned income value measured by the planning model.

3.3 Revised Model Construction Mechanism

In the application of PPP model for transportation infrastructure construction, according to the characteristics of PPP, the multi-stakeholder model of financing mode and the special economic characteristics of transportation infrastructure construction, the income distribution is mainly affected by three factors, namely, subjective factors and systems. Sexual factors and social factors, and three factors have a positive impact on income distribution.

The main factors include cooperation income, the proportion of capital investment, the degree of contract execution, the degree of innovation contribution and risk tolerance; institutional factors include government intervention, the legal system, transportation policy and market changes; social factors include social environment, line restructuring, Fares fluctuations and quality of service. In this paper, the subjective factor is selected as the main influencing factor, and the institutional and social factors are respectively classified into the risk-bearing evaluation index system of the transportation infrastructure construction PPP project. As a risk factor, it has an impact on the project income distribution, and its main influence. The mechanism is shown in the Fig. 1.

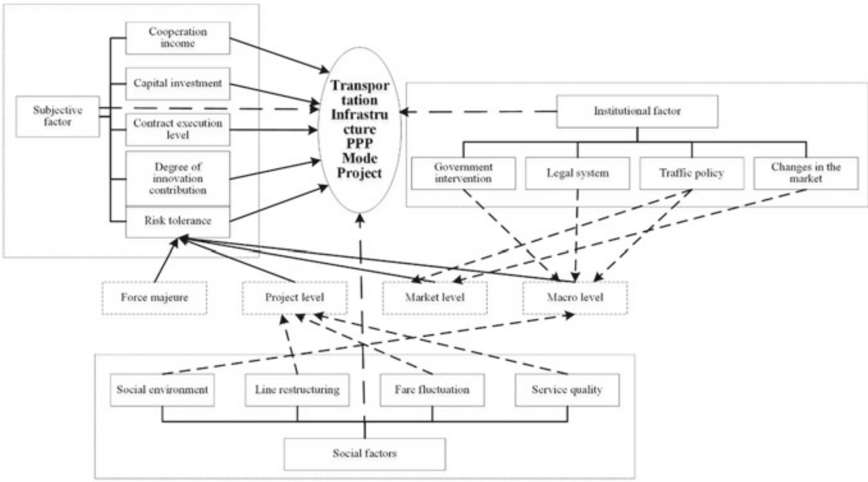

Fig. 1 Revised model construction mechanism diagram

The modified Shapley value method is not only simple in setting up the model and correcting the solution process, but also ensures the uniqueness of the income distribution plan, even if it is in a loss state. And given the characteristics of transportation infrastructure construction, most of the projects that were handed over during the construction and operation period are in a state of loss. The modified Shapley value method can distribute income even in the case of losses. Also, such projects are generally accompanied by factors such as the government's feasibility gap subsidy, and can also be considered by the influencing factors in the revised Shapley value, and can be adjusted according to the implementation, so that the model can be more in line with the actual situation.

4 Empirical Research

4.1 Empirical Case Selection

The total length of the X urban rail transit line is 233.6 km. Line 2 is the main skeleton line in the north-south direction of the X city rail transit network. Line 2 can cover the main north-south passenger flow tasks of X city, as the main city and the new city. The north-south fast-track has become the largest passenger route in the X-city rail transit network.

The first phase of Line 2 was laid south to north, with a length of 23.647 km and 23 stations. The preliminary design estimate for the first phase of X Urban Rail Transit Line 2 is 205,167.83 million yuan, and the technical and economic indicators are 86,762,300 yuan/positive line kilometers. The capital ratio of this project is 35%. The first phase of Line 2 adopts the PPP operation mode, and the transaction structure is A + B mode, that is, the electromechanical equipment (Part B) construction-operation-transfer (BOT) mode. After the A and B projects are split, all the Part B investments are made. The capital of 35% is estimated, and the total investment of PPP projects is 6.316 billion yuan.

The X municipal government authorizes the implementing agency to determine social investors through bidding. The government has a good understanding of the project's operating conditions, exercised its supervisory responsibilities, and appropriately participated in the project company. The social investor and the municipal government investor signed a joint venture cooperation contract with X City Rail Transit Development Co., Ltd. to establish a project company (SPV). After the executing agency signs the contract agreement and other contract documents on behalf of the government and the project company, SPV obtains the concession and is responsible for investing in the construction of part B of the second phase of the second line during the concession period, symbolically renting part A facilities and conducting The operation of the first phase of Line 2 is responsible for the maintenance of the project and the maintenance of operational investment. In the meantime, to ensure the safety of project construction and operation, the quality of service, especially the provisions of the franchise agreement, the government must exercise the right to supervise the industry for the project company. At the end of the concession period, the project company ensures that the equipment and the charity are transferred to the X municipal government department or other organization designated in the contractual agreement.

4.2 Shapley Value Income Distribution Without Considering the Influencing Factors

(1) *Project cost benefits*

The financial analysis of the PPP project of X City Rail Transit Line 2 is 27 years, of which the construction period is 2 years (2017–2019), and the trial operation starts in July 2019, entering the 25-year franchise period, which is 2019~2044 years. The project capital is temporarily considered as 35%. In the capital, the ratio of government and social capital stocks is 5%: 95%. The government plans to invest 110,523,800 yuan and the social capital is planned to invest 209,995,600 yuan. Debt funds totaled 410,516,500 yuan, according to 22-year loans (2 year grace period, 20 year repayment period).

The ticket system income refers to the A city operating fare rate and average station spacing, average distance data, combined with the average distance and the average station spacing of the passenger flow forecast of the project, and calculated at the current price to obtain the initial, near and long term of the project. The average fare rates are 0.2512, 0.2509, and 0.2541 yuan/person-km. The operating income consists of ticket revenue and non-ticket revenue. Non-ticket revenue mainly includes advertising, communication, retail and other business development income directly related to the project facilities. According to the operation of other cities, the non-ticket net income is temporarily 10% of the ticket revenue. Calculation. Calculated by profit and loss analysis, the net income totaled RMB 2,373,008,400. The costs incurred by the project company include operating costs, amortization and financial expenses. Operating costs are mainly composed of labor costs, electricity costs, maintenance costs, operating expenses, and management fees. The total cost of the project was estimated to be 1,545,202,500 yuan.

The discount rate is 2.93% (average coupon rate of X city local bonds in 2016), the long-term loan interest rate is 4.9%, the reasonable profit rate is 10.98%, and the annual average non-ticket net income is temporarily calculated at 10% of the ticket revenue. Under the premise that the financial internal rate of return after the project capital income tax is 6.5%, the total revenue of the project company during the concession operation period is 22.573 billion yuan, the income from other businesses is 2.257 billion yuan, the net income is 23.730 billion yuan, and the total cost is 15.452 billion yuan. The total amount was 8.278 billion yuan, the income tax paid was 2.192 billion yuan, the net profit was 6.068 billion yuan, and the statutory reserve fund was 608 million yuan, and the profit available for distribution was 5.478 billion yuan.

(2) *Estimation of the income distribution*

The two core stakeholders in the PPP model of X City Rail Transit Line 2 can form a cooperative game (N, V) under the PPP model, where N includes two core stakeholders, namely the X city public sector and The private sector, while V refers to the different benefits obtained from the implementation of different subsets, that is, the eigenvalues derived from the established eigenfunctions.

According to the Shapley model, all the cases in which the X-city rail transit line 2 PPP model X municipal public sector E participates and the benefits that should be distributed are:

$$\begin{aligned} Y_E(V) &= \sum_{E \in S} W(|S|)[V(S) - V(S \backslash E)] \\ &= V(E)/2 + [V(E, T) - V(T)]/2 \end{aligned} \tag{7}$$

X City Rail Transit Line 2 PPP mode Private sector T participation in all cases and the benefits that should be distributed are:

$$\begin{aligned} Y_T(V) &= \sum_{T \in S} W(|S|)[V(S) - V(S \backslash T)] \\ &= V(T)/2 + [V(T, E) - V(E)]/2 \end{aligned} \tag{8}$$

From the previous analysis, the construction and operation income of the PPP model of X City Rail Transit Line 2 is available, $V(E, T) = 547{,}771{,}100$ yuan, $V(E) = 69{,}434{,}100$ yuan, and $V(T) = 3{,}864{,}105{,}900$ yuan.

Table 1 Changes in the income level of core stakeholders in the PPP model of X city line 2 (unit: 10,000 yuan)

Case project core stakeholders	Seize the proceeds separately	Distribution income in PPP mode	Income increase	Income increase (%)
Public sector E	69,434.71	115,402.22	45,967.51	66.20%
Private sector T	386,401.59	432,369.10	45,967.51	11.90%
Total	455,836.30	547,771.32	91,935.02	20.17%

Therefore, the income distribution quotas $Y_E(V)$ and $Y_T(V)$ obtained by the public sector E and the private sector T in the PPP model of the X-city rail transit line 2 are (unit: 10,000 yuan):

$$\begin{aligned} Y_E(V) &= V(E)/2 + [V(E, T) - V(T)]/2 \\ &= 69434.71/2 + (547771.31 - 386401.59)/2 = 115402.22 \end{aligned} \tag{9}$$

$$\begin{aligned} Y_T(V) &= V(T)/2 + [V(T, E) - V(E)/2 \\ &= 386401.59/2 + (547771.31 - 69434.71)/2 = 432369.10 \end{aligned} \tag{10}$$

From the above calculations, after the PPP project of X City Rail Transit Line 2 is completed, the public sector E can benefit 115,504,200 yuan in the corporation, the income of the project, and the private sector T can cooperate in the corporation income of the case project. The gain was 432,369,100 yuan. After using the PPP model, the benefits have increased to some extent, which also proves the effectiveness of using the PPP cooperation model (Table 1).

4.3 Shapley Value Return Distribution Considering Influencing Factor Correction

(1) *Revised model construction*

According to the analysis of the factors affecting the income distribution of the PPP model by scholars [16, 17], combined with the characteristics of transportation infrastructure construction, the factors affecting the income distribution are summarized. Institutional, initiative and social factors will have a positive impact on income distribution. Capital investment, risk-taking, contract execution, innovation contribution, financial subsidy, return method, incentive system and other factors are positively related to income distribution. Based on the impact mechanism constructed in the previous section, this paper selects the four main influencing factors of capital investment proportion, risk commitment degree, innovation contribution degree and contract execution degree, and corrects the established income distribution model.

Four factors affecting the PPP mode income distribution of X City Rail Transit Line 2 are combined to establish a set of influencing factors $J = \{j\}, j = 1, 2, 3, 4$. In the PPP mode of X City Rail Transit Line 2, the corrected measurement index of the i-th core stakeholders on the factors affecting the j-th revenue distribution is α_{ij}. The correction coefficient matrix A is constructed according to the influencing factor correction coefficient:

$$\mathrm{A} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} \end{bmatrix} \tag{11}$$

Normalize matrix A to get matrix A′. In the calculation of the income distribution plan for the PPP mode of the X city rail transit line 2, it will be applied to the relevant experts, who use the traffic infrastructure construction as the special product field to score the influencing factors, thus obtaining the factor matrix of the four impact categories $\lambda = \begin{bmatrix} \lambda_1 & \lambda_2 & \lambda_3 & \lambda_4 \end{bmatrix}^T$, and $\mathrm{A} \cdot \lambda = \beta = \begin{bmatrix} \beta_1 & \beta_2 \end{bmatrix}^T$ calculates the income distribution of the public sector and the private sector in the PPP model of X City Rail Transit Line 2 by the previous article. The four types of influencing factors mentioned are the combined effects of β_1 and β_2.

At this time, the adjusted income distribution of the PPP project alliances of the public sector and the private sector in X City are:

$$Y_E(V)' = Y_E(V) + (b_1 - 1/n) \times V(E, T) \tag{12}$$

$$Y_T(V)' = Y_T(V) + (\beta_1 - 1/n) \cdot V(E, T) \tag{13}$$

In the PPP model of X City Rail Transit Line 2, because of the complexity of the capital investment in the PPP model proposed in the previous section, this paper proposes to select the capital investment of the public and private sectors of X City and the financial subsidies given by X municipal government departments as the basis for calculation. Government departments accounted for 5% of capital investment, and private sector capital investment accounted for 95%. According to the subsidy model, X city government's feasibility subsidy during the concession operation period was about 10,796.43 million yuan, which can be used to calculate the public sector of the X city and the private sector. The respective capital investment ratios are 0.36 and 0.64, that is, the capital input weight vector $(a_{11}, a_{21}) = (0.36, 0.64)$.

Determine the overall risk degree vector of both parties. This paper adopts the analytic hierarchy process. According to the actual situation of X City Rail Transit Line 2, the public sector and private sector of X City are the first levels, and the risks identified in the whole cycle are divided into macroscopic. Level, market level, project, level, force majeure, and each category contain multiple risk factors of three levels, based on a total of 50 risk factors identified, filtered and combined, and then determined by analytic hierarchy process The weight of the risk index of the X-ray rail transit line 2 is calculated by the expert grading analysis method, and the weight vector $(a_{12}, a_{22}) = (0.42, 0.58)$ of the risk-bearing degree distribution is obtained.

The income distribution of the PPP mode of X City Rail Transit Line 2, the impact of the sudden situation on the line construction and operation should be considered. Before the end of the franchise period, the emergency is difficult to determine and preliminary judgment is required. And estimate the overall revenue loss of the line caused by the possible unexpected events. This paper tentatively sets the level of innovation contribution of the two core stakeholders and can do everything possible to cope with the emergencies in the line construction, operation, that is, the innovation contribution factor $(a_{13}, a_{23}) = (0.50, 0.50)$.

Also, in the PPP model income distribution of X City Rail Transit Line 2, this paper assumes that the public sector and private sector of X City are expected to meet the requirements of quality and schedule by the contract documents in the whole process of construction and operation of the line. Each phase completes its respective mission objectives intact, that is, this paper assumes that the contract execution factor $(a_{14}, a_{24}) = (0.50, 0.50)$.

Each of the influencing factors has different impacts on different fields and even different construction projects. Therefore, when determining the λ coefficient matrix of the influencing factors of income distribution under the PPP mode of X City Rail Transit Line 2, it is necessary to consider the X city. The actual situation and the characteristics of transportation infrastructure construction. This paper selects the expert scoring method and obtains the income distribution effect $\lambda = (0.41\ 0.31\ 0.16\ 0.12)^{T}$ of the four factors of capital investment, the degree of risk commitment, the degree of innovation contribution and the degree of contract execution on the PPP model of X City Rail Transit Line 2.

(2) *Estimation of the income distribution*
According to the formula, the overall affected degree β_1, β_2 and income distribution of the public and private sectors of the Shapley model are corrected under the influence mechanism of the revenue distribution of the transportation infrastructure PPP model (unit: 10,000 yuan):

$$\begin{aligned}\left[\beta_1\ \beta_2\right]^{T} &= A \cdot \lambda \\ &= \begin{bmatrix} 0.36\ 0.42\ 0.5\ 0.5 \\ 0.64\ 0.58\ 0.5\ 0.5 \end{bmatrix} \cdot \left(0.41\ 0.31\ 0.16\ 0.12\right)^{T} \\ &= \left[0.4178\ 0.5822\right]^{T}\end{aligned} \tag{14}$$

$$\begin{aligned} Y_E(V)' &= Y_E(V) + (\beta_1 - 1/n) \cdot V(E, T) \\ &= 115402.22 + (0.4178 - 1/2) \cdot 547771.31 = 70375.42 \end{aligned} \tag{15}$$

$$\begin{aligned} Y_T(V)' &= Y_T(V) + (\beta_2 - 1/n) \cdot V(E, T) \\ &= 432369.10 + (0.5822 - 1/2) \cdot 547771.31 = 477395.90 \end{aligned} \tag{16}$$

Before the model was revised, the increase in the income allocated by the public sector in X City was much larger than that in the private sector. The increase in income

Table 2 Changes in income level of the core stakeholders of the PPP project of X city line 2 (unit: 10,000 yuan)

Case project core stakeholders	Seize the proceeds separately	Distribution income in PPP mode	Income increase	Income increase (%)
Public sector E	69,434.71	70,375.42	940.71	1.35%
Private sector T	386,401.59	477,395.90	90,994.31	24%
Total	455,836.30	547,771.32	91,935.02	20.17%

made the government agencies in X City have the incentive to introduce social capital into the PPP model while improving the overall line construction operating income. Help develop emerging investment models and coordinate the allocation of government budgets. However, after the model was revised, the private sector's revenue increased even more. As shown in the table, the private sector has a higher proportion of investment and a higher risk than the public sector in the actual operation. Require a higher return on earnings (Table 2).

5 Conclusion

Under the background of China's current economic environment and policy system, Part B of City Rail Transit Line 2 adopts a PPP financing model. After constructing the income distribution model and correcting it, the income distribution plan of the case will distribute the income of the PPP mode of transportation infrastructure construction. It has good reference significance. The research conclusions of this paper mainly include the following three points:

(1) *The revised Shapley model income distribution is more scientific and fair.* After the revision, the Shapley revenue distribution model will actually allocate part of the project revenue to the private sector. After considering the influencing factors, the distribution model will be more in line with the actual situation of the private sector investment and the high risk.
(2) *The PPP model can bring about an increase in the revenue of the transportation infrastructure.* Before considering the correction factors, the government's distribution income is higher than that of the private sector. After considering the influencing factors, the efficiency changes before and after, and the private sector obtains higher income distribution because of the high investment and high risk. And its increase is greater than the government sector.
(3) *The impact mechanism of the construction can provide the basis for adjusting the income distribution.* Based on the consideration of the factors affecting the distribution of income, based on the impact mechanism constructed, the principle of distribution of the private sector in terms of equity can be guaranteed, and the private sector can be selected to cooperate with government

agencies in the process of construction and operation of transportation infrastructure. Effective behavioral measures in the direction of guidance can improve the overall revenue, efficiency of transportation infrastructure construction and operation, and ultimately create social and economic benefits for the area where the transportation infrastructure is located.

However, there are still some shortcomings in the research of this paper. First of all, the social benefits of the PPP model for transportation infrastructure construction are difficult to quantify. Secondly, when constructing the PPP mode impact mechanism of traffic infrastructure construction, it is difficult to quantify each factor by implementing the influencing factors on the indicators. Also, because the relevant data of transportation infrastructure construction is difficult to collect, in the research of this paper, the internal data measurement and analytic hierarchy process are combined with expert judgment. The method has certain empirical influence, and there may be subjective bias and the scheme. The calculation results have a certain impact.

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Relationship Between Industrial Competition Network and Innovation Performance of Specialized Towns in Guangdong Province

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Abstract The specialized town is one of the characteristic industrial organization forms, the representative form of China's industrial clusters and the main component of the regional economy in Guangdong province. They are all in traditional manufacturing industries, which causes the significant competition among the specialized towns. This paper adopts the complex network method and adds the geographical distance into the general market model, aiming to optimize the measure of competition. It analyzes the network structures and the influence on the innovation performance of specialized towns. The research results show that the competition network of specialized towns in Guangdong has a small world effect; whether it is alone or in combination with the intensity of inward points, there is a significant inverted U-shaped relationship between the intensity of the outward point and the innovation performance.

Keywords Specialized towns · Complex network · Competitive relationship network · Performance research

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1 Introduction

After the 1990s, the industrial clusters have been developing rapidly in Guangdong, Fujian and Zhejiang. In Guangdong, the specialized town is one of the prominent forms of industries clusters [1] and became the important element of regional economy in Guangdong [2]. Now there are 399 specialized towns in Guangdong, mainly distributing in 30 traditional manufacturing industries. Moreover, the competition among these specialized towns is significant because of the existence of the geographical proximity and the type similarity in industry.

The competitive relationship among specialized towns is inter-industry relationship. The research with traditional way on inter-industry competition originated from SCP paradigm, especially in the industrial organization of special industries. Furthermore, the theoretical scholars have developed the industrial association research under the input-output theory. Limited by the technical methods, above two types research just can describe the mainstream competitive questions but not in more complex industrial competition reality on the whole because of the small number of competitive subjects and the simple measure. Recently, the emergence of complex network analysis provides the possibility of the whole competitive relationship research.

In the research of industrial organization and industrial association, the common measures of competition are marginal profit [3], market concentration, profit elasticity index [4] and Lerner index. Some scholars used such as corporate homogenization degree [5], enterprise competitive relationship network structural index [6] to describe competition among enterprises. Yang [7] is the first to introduce complex network analysis method into industrial organization study, separately constructing the complex network of enterprise competition and product competition, and conducting empirical research. Based on the existing research, the research on competitive relationship from the perspective of complex networks mainly focuses on two-mode networks among enterprises. Yuan [8], Ou [9, 10], Gao [11] studied specific industries: home appliances, automobiles, logistics and further analysis of the industry's internal enterprises competition, enterprise-product competition network relation.

Furthermore, with the development of the research objects and perspectives, a small number research began the analysis of the inter-industry competitive relationship. Li [12] studied the specialized town economy of the Pearl River Delta, the same or related products as the link, and found the complex network characteristic from the product competition network. Huang [13] proposed a two-dimension inter-industry competition pressure model, composed of the resources and market competition component, and found the directional, heterogenous, symmetrical and proportional feature in inter-industries competitive pressure on the basis of the input-output competitive pressure measurement method.

Competition and Cooperation are two always being focused on and universal relationship among enterprises and industries. Based on the idea of free market, the motivation of competition to the organization among enterprises and industries is obviously more important than cooperation, and the mechanism and effect of this motivation on the innovation of maintaining the organization's sustainable development are direct and obvious. The research on inter-enterprises competition to innovation always is the point that the area of enterprises management, technological innovation and the theory of industrial organization focus on. However, the relationship among industries especially the competition got insufficient attention because of the limitations of data acquisition, technology and methods. Specialized town is a particular form of industrial organization and a significant perspective to study inter-industry competition. Thus, this study selects some specialized towns based on characteristic industries as research objects, uses the complex network to measure the competitive relationship, and adds the geographic distance variation to optimize the competitive relationship measurement model, aiming to enhance the reality explanatory of the model, make it more suitable to explain the competition among industries of the specialized towns and achieve the purpose of better revealing the law of competition affecting innovation under this situation. Furthermore, data acquisition has always been a major constraint on existing industries cluster research, mainly adopting questionnaire and cases analysis. This study uses the only big data about industries cluster in China to construct ten year specialized towns overall networks, with certain innovation in data and perspective.

2 The Construction and Analysis of Competitive Relationship Network in Specialized Towns

2.1 Data Sources

The source of data in this paper is from the big data application and service platform of specialized towns in Guangdong Province. It's the first database about specialized towns with large amount of data and comprehensive industrial information in China. This data is more accurate and comprehensive because it contains the overview of characteristic industries in each specialized town, macro industry analysis, regional industry analysis and comparison, town industry analysis and industry search analysis for many years and so on.

This paper selects the top 10 specialized towns' data in 20 characteristic industries in Guangdong from 2006 to 2015, including the output value of each characteristic industry of each specialized town, the total output value of characteristic industries of each specialized town, the total output value in the province of each characteristic industry and so on. The 20 characteristic industries are shown in Table 1.

Table 1 20 characteristic industries in Guangdong province

Type	Index
	Industry
The primary industry	Grain, seafood, aquaculture cash crop
The secondary industry	Ceramics, food, building materials, home appliances, handicrafts, hardware, printing and packaging, textiles and garments, medicine, footwear, electronics, machinery, furniture and lighting
The tertiary industry	Logistics and tourism

2.2 Network Construction

This paper will construct a directed weighted competition network for specialized towns in Guangdong. With the specialized towns as the nodes in the network, when more than 1 common industry is developed between two specialized towns, they are connected, thus obtaining the competitive relationship Boolean network model of specialized towns in Guangdong. In addition, considering the actual market competition, the competitive relationship has asymmetry and strong heterogeneity, and specialized towns mostly develop traditional industries with low added value and high transaction costs, which the transport cost is the main chain affecting. Under the condition of the same product quality, the closer the distance among the specialized towns, the more obvious the competition. Therefore, the geographical distance is an important factor affecting the intensity of competitive relationship. In order to describe the asymmetry and strong heterogeneity and geographical distance of the competitive relationship, this paper combines the market commonality model and the gravity model, while introducing the direction and weight on the edges, the distance variation between each specialized town is innovatively improved to be added in.

According to the following formula, construct a specialized town directed weighted competition network model:

$$M_{AB}^{*} = \sum_{\kappa \in set_A \cap set_B} \left[\frac{\mathrm{P}_{A\kappa}}{\mathrm{P}_A} \times \frac{\mathrm{P}_{B\kappa}}{\mathrm{P}_\kappa} \right] \times d_{AB}^{-1} \tag{1}$$

M_{AB}^{*} is the market commonality that specialized town B relative to A. k is the type of different characteristic industry. P_{Ak} is the output value of the k^{th} characteristic industry in specialized town A. P_A is the total output value of characteristic industries in specialized town A. P_{Bk} is the output value of the k^{th} characteristic industry in specialized town B. P_k is the total output value of industry k in Guangdong. P_{Ak}/P_A represents the importance that the characteristic industry k to specialized town A. P_{Bk}/P_k indicates that the output value of the k^{th} characteristic industry in specialized town B accounting for the proportion of the total output value of industry k in Guangdong. d_{AB} is the shortest distance between A and B.

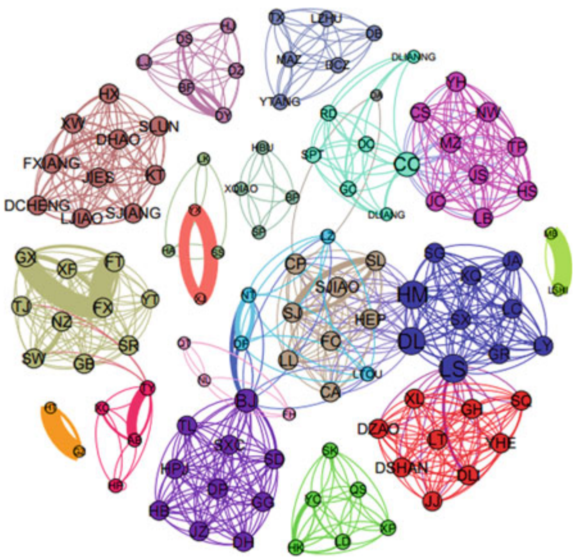

Fig. 1 The direction weighted specialized town competitive relationship network in 2006

Through the improved directed weighted specialized town competitive relationship network model, using Gephi to obtain 10 directed weighted competitive relationship network in Guangdong from 2006 to 2015 that the specialized towns as the nodes, the competition among the specialized towns as the edges, the market commonality M^* as the weight (similar to Fig. 1).

2.3 Network Analysis

Observing the overall attributes of the competition network from several attribute characteristics: From 2006 to 2015, the average weighted degree of the network in Guangdong fluctuated around 0.01, indicating that the competition intensity is relatively stable. The network density is maintained at 0.052, and the distribution of competition is sparse and scattered. The specialized towns only compete with that develop the same or similar industries for the same raw material. For example, Xintang jeans industry and Lishui socks industry complete with each other for cotton, polyester, dyes, needles, buttons, zippers and so on. Inter-industry competition in Guangdong is not obvious, so the characteristic industries in Guangdong still have a great development space. The average clustering coefficient is greater than 0.9 and the change is not large, so it is in a relatively stable state, indicating that the agglomeration of competitive relationship in the network is strong, with obvious and stable clustering effect. The change of average shortest path length in ten years is small. It means that on average a specialized town can establish competition with

Table 2 The overall attribute characteristics of the network

Year	Attribute characteristics of the network			
	Average degree	Graph density	Average clustering coefficient	Average shortest path length
2006	0.013	0.06	0.926	1.252
2007	0.01	0.054	0.946	1.219
2008	0.011	0.052	0.982	1.133
2009	0.011	0.051	0.983	1.124
2010	0.01	0.052	0.977	1.172
2011	0.011	0.052	0.990	1.176
2012	0.011	0.051	0.990	1.317
2013	0.01	0.052	0.985	1.286
2014	0.009	0.052	0.985	1.283
2015	0.01	0.051	0.986	1.279

others just through 2 intermediate specialized towns. It reflects that the competitive relationship is easily created in the network (Table 2).

In addition, according to the WATTS point of view, combined with the analysis of the average clustering coefficient, the network in Guangdong from 2006 to 2015 has a higher average clustering coefficient and a smaller average shortest path length. Therefore, the competitive relationship network has a significant, stable small world effect.

Because of the following research need, the analysis of the node structure properties only considered the index of the intensity of point. In directed weighted network, the intensity of point is an indicator that measures the sum of the strength of the relationship sent and received by a single node in the network. It can be divided into intensity of the outward point and intensity of the inward point. The later measures the sum of the edge weight pointing to a node, representing the sum of the competitive pressures that the node is subjected to by other nodes. The former measures the sum of the edge weight that one node pointing to others, representing the sum of the competitive pressures that this node applies to other nodes. The edge weight represents the strength of the competition between two nodes.

By calculating the intensity of the outward point and intensity of the inward point of each specialized town in the network from 2006 to 2015, the top 10 each year are selected (Table 3).

From the perspective of the intensity of outward point, Beijiao Town is the specialized town with a high outward point intensity value in the competition network for ten years, followed by Fengxi District, Guzhen Town, Dayong Town, Guxiang Town and Xinjin Street. It shows that these six specialized towns have exerted great competitive pressure on others in Guangdong in the past ten years. They are in a leading position in their industrial fields and have relatively obvious competitive advantage. Then from the inward point intensity, Fengtang Town and Dongfeng Town are the

Table 3 2006–2015 high intensity of point of specialized town (descending order)

Year	Attribute characteristics of the network		
	The intensity of outward point	Specialized town's name-abbreviation	The intensity of inward point
2006	FX, GZ, MB, YX, AB, DY, SJ, XJ, DLI, BJ	Fengxi District-*FX*, Guzhen Town-*GZ*, Maba Town-*MB*, Yongxiang Street-*YX*, Anbu Town-*AB*, Dayong Town-*DY*, Shijie Town-*SJ*, Xinjin Street-*XJ*, Dali Town-*DLI*, Beijiao Town-*BJ*, Lubao Town-*LB*, Leliu Street-*LL*, Nantou Town-*NT*, Guxiang Town-*GX*, Daliang Street-*DaL*, Lezhu Town-*LZ*, Zhangmutou Town-*ZMT*, Changping Town-*CP*, Shiwan Street-*SW*, Rongui Street-*RG*, Guicheng Street-*GC*, Baini Town-*BN*, Lunjiao Street-*LJ*, Sanjiao Town-*SJ*, Pinggang Town-*PG*, Machong Town-*MC*, Longjiang Town-*LoJ*, Qingxi Town-*QX*, Changan Town-*CA*, Fengtang Town-*FT*, Hetang Town-*HT*, Lishi Town-LS, Tongyi Street-*TY*, Banfu Town-*BF*, Dongfeng Town-*DF*, Dongsheng Town-*DS*, Chencun Town-*CC*, Shilong Town-*SL*, Fengxin Street-*FXS*, Nanzhuang Town-*NZ*, Daojiao Town-*DJ*, Yujiao Town-*YJ*, Shawan Town-*SAW*	FT, GX, HT, LS, XJ, TY, YX, NT, BF, DF
2007	GZ, YX, DY, AB, BJ, LB, LL, XJ, DLI, NT		HT, XJ, DF, BF, YX, TY, SW, LS, FT, DS
2008	FX, GZ, YX, GX, BJ, DY, AB, XJ, DaL, LZ		FT, GX, HT, XJ, CC, YX, FX, TY, BF, DF
2009	FX, GZ, YX, DY, BJ, GX, DaL, AB, XJ, ZMT		FT, GX, HT, XJ, YX, CC, BF, FX, TY, DF
2010	XJ, GZ, BJ, FX, CP, YX, DY, GX, DaL, SW		YX, HT, NT, DF, XJ, FT, BF, GX, SL
2011	FX, RG, DaL, GZ, XJ, BJ, ZMT, SW, GC, BN		LJ, FT, NT, GX, DF, YX, HT, RG, FX, CP
2012	FX, RG, GZ, DaL, BJ, GX, LJ, DY, SW, DLI		FT, HT, NT, GX, DF, LJ, RG, FX, BF, ZMT
2013	FX, RG, BJ, SW, LJ, GX, SJ, CP, BN, AB		FT, NT, GX, FXS, DF, RG, NZ, FX, ZMT, SAW
2014	FX, LJ, SW, PG, BJ, MC, CP, GX, RG, LoJ		FT, GX, NT, DF, ZMT, NZ, SAW, DJ, FX, YJ
2015	FX, RG, BJ, LJ, PG, QX, LoJ, CA, NT, MC		FT, GX, NT, DF, RG, YJ, ZMT, SAW, SW, FX

specialized towns with high inward point intensity in the network in the past ten years, followed by Guxiang Town, Fengxi District, Nantou Town and Hetang Town. It reflects that these six specialized towns have suffered the competitive pressure from others in the past ten years, and they are more constrained in the development process.

3 The Relationship Between Competition Network and Performance of Specialized Towns

3.1 Model Construction

Now studies have shown that a certain degree of competition is good for the improvement of corporate performance, but excessiveness will have a negative impact on performance. Aghion et al. [14] put forward the model of gradual innovation, that is, the *Inverted U-type* hypothesis of enterprise competition and innovation performance. Jiao-ping Yang explored the impact of the degree of competition within the industries on innovation performance, and concluded that competition among enterprises has the dual effect of promoting and hindering innovation. Li [15] found that as the competition deepened, enterprises under pressure will increase the intensity of innovation, but this will lead to the reduction of available resources, the decline in innovation and have an inverted U-shaped impact on the innovation performance.

On the basis of existing research results, this study holds that competition among specialized towns will also have an inverted U-shaped effect on their performance. The competitive relationship among the specialized towns is described from two indicators of outward and inward point intensity.

When a specialized town exerts appropriate competitive pressure on others, it will form a certain degree of positive competition, promote the enterprises in this specialized town to speed up the knowledge overflow, so as to improve its innovation performance. However, when the competitive pressure exerted is too large, it will induce vicious price competition, destroy the competitive environment and hinder the improvement of innovation performance.

When a specialized town is subjected to appropriate competitive pressure from others, in order to cope with market changes, the enterprises in this specialized town will increase the intensity of innovation, so that innovation performance will have been improved to a certain extent. However, when the competitive pressure is too large, the risks faced by enterprises will continue to increase, resulting the enterprises more conservative when making technological innovation decisions, and increasing constraints, so that innovation performance will decline. Therefore, this paper presents hypothesis 1 and hypothesis 2:

Hypothesis 1: The outward point intensity of a specialized town has an inverted U-shaped effect on its innovative performance.

Hypothesis 2: The intensity of the inward point in a specialized town has an inverted U-shaped effect on its innovative performance.

The data selected 2006–2015 of specialized towns the amount of patent authorization as the variable (*Y1*). The two independent variables are measured by outward point intensity (*X1*) and inward point intensity (*X2*) in the directed weighted network. The number of characteristic economic enterprises and the intensity of public science and technology input are analyzed as control variables (*Z*).

First, study the impact of *X1* on innovation performance (*Y1*). Build model one, as follows:

$$Y1_{i,t} = a_i + b_1 X1_{i,t} + b_2 (X1_{i,t})^2 + b_3 Z_{i,t} + e_{i,t} \tag{2}$$

$X1^2$ represents the U-type relationship between *X1* and *Y1*, if the coefficient b_2 is significantly positive, there is a positive U-type relationship between *X1* and *Y1*; if the coefficient is significantly negative, for the inverted U-type relationship; *i* represents one specialized town, *t* represents the year.

Secondly, the influence of *X2* on *Y1* is studied. Build model two similarly, as follows:

$$Y1_{i,t} = a_i + b_1 X2_{i,t} + b_2 (X2_{i,t})^2 + b_3 Z_{i,t} + e_{i,t} \tag{3}$$

Finally, under the joint action *X1* and *X2* impact on *Y1*. Build model three:

$$Y1_{i,t} = a_i + b_1 X1_{i,t} + b_2 (X1_{i,t})^2 + b_3 X2_{i,t} + b_4 (X2_{i,t})^2 + b_5 Z_{i,t} + e_{i,t} \tag{4}$$

3.2 Empirical Analysis

First, fixed effect test and random effect test are performed on models one to three (as shown in Table 4). The test results show that the F-values of fixed effect test are all significantly greater than 0, and the P-values are 0, which indicates that the fixed effect model is significantly better than the hybrid OLS model. The P-values

Table 4 Fixed effects test and fixed effects test

Equations in model	Test result		
	Fixed effects test		Random effects test
	F-value	P-value	P-value
(1)	16.59402	0	0
(2)	13.25269	0	0
(3)	15.82964	0	0

of random effect test are all 0, indicates that the random effect model is also better than the hybrid OLS model. Therefore, the individual effect of model one to three is significant, and the fixed effect model or random effect model should be selected.

Because of the lack of some data in the platform of specialized town, this study selected 41 specialized towns with complete data as the empirical analysis object. Compared with 399 specialized towns in Guangdong Province, the sample distribution has a great randomness, the effect related to the samples should be regarded as random distribution. Therefore, in order to infer the whole through the sample, the random effect model should be used first, then through the Hausman test to determine whether to accept the hypothesis of individual effect is not related to other explanatory variables, if accept, the random effect model is used, otherwise, the fixed effect model is used.

Based on the model 1, 2 and 3, this paper discusses the relationship between the innovation performance and the inward and outward point intensity of the competition among specialized towns in Guangdong province. The random effect model is first established (as shown in Table 5, 6, 9), followed by a Hausman test (as shown in Table 7). From Table 7, the model 1, the P-value of the test results is 0.0007, it means using random effect model will lead to endogenous problems, indicating that the fitting results of the fixed effect model is better (as shown in Table 8). The P-values of the four variable coefficient estimates of *X1*, $X1^2$, *QYS* and *TRQD* in the model are less than 0.01, which shows that the model can explain the dependent variable well. Among them, the coefficient of *X1* is positive, the coefficient of $X1^2$ is negative, so hypothesis 1 is established. The number of characteristic economic

Table 5 Random effects test rest in model 1

Explanatory variables	Model 1			
	Coefficient	Std. Error	t-Statistic	Prob.
C	15.11897	90.92080	0.166287	0.8680
X1	32934.09	5580.621	5.901510	0.0000
$X1^2$	−499930.6	71048.41	−7.036477	0.0000
QYS	0.259824	0.038054	6.827790	0.0000
TRQD	35.48976	11.19547	3.170011	0.0016

Table 6 Random effects test rest in model 2

Explanatory variables	Model 2			
	Coefficient	Std. Error	t-Statistic	Prob.
C	238.0877	101.9606	2.335095	0.0200
X2	2350.410	5044.629	0.465923	0.6415
$X2^2$	−24246.57	44045.38	−0.550491	0.5823
QYS	0.285197	0.040980	6.959365	0.0000
TRQD	34.88674	12.13479	2.874936	0.0043

Table 7 Hausman test result in model 1, 2, 3

Model	Hausman test result			
	Test summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
(1)	Cross-section random	19.335423	4	0.0007
(2)		4.165863	4	0.3840
(3)		34.430682	6	0.0000

Table 8 Fixed effects test rest in model 1

Explanatory variables	Model 1			
	Coefficient	Std. Error	t-Statistic	Prob.
C	74.28172	79.71331	0.931861	0.3520
X1	31449.10	6559.055	4.794762	0.0000
$X1^2$	−526903.8	80388.54	−6.554464	0.0000
QYS	0.240702	0.047592	5.057563	0.0000
TRQD	33.82171	11.66820	2.898623	0.0040

enterprises in specialized towns and the intensity of public science and technology investment have a significant positive impact on innovation performance.

The accompanying probability of the model 2 test results is 0.3840, so used the random effect model. The results are consistent with the hypothesis 2, but not significant. In addition, the results of control variables are the same as those of model 1. Based on the model 3, a random effect model is established (as shown in Table 9), and through Hausman tested (as shown in Table 7), it can be seen that the accompanying probability of the model 3 test results is less than 0.1, so used the fixed effect model (as Table 10). From the fixed effect model 3, the coefficient of *X1* is significantly positive, the coefficient of $X1^2$ is significantly negative, and there is a significant inverted U-shaped relationship between the intensity of outward point and the innovation performance of specialized town, which validates the hypothesis 2. However,

Table 9 Random effects test rest in model 3

Explanatory variables	Model 3			
	Coefficient	Std. Error	t-Statistic	Prob.
C	36.34496	91.74522	0.396151	0.6922
X1	35360.75	5731.144	6.169929	0.0000
$X1^2$	−512008.3	71393.38	−7.171649	0.0000
X2	−3442.873	4743.420	−0.725821	0.4684
$X2^2$	7718.088	40909.81	0.188661	0.8505
QYS	0.258364	0.036467	7.084959	0.0000
TRQD	35.80786	11.15709	3.209426	0.0014

Table 10 Fixed effects test rest in model 3

Explanatory variables	Model 3			
	Coefficient	Std. Error	t-Statistic	Prob.
C	64.61247	93.74325	0.689249	0.4911
X1	31785.78	6337.964	5.015140	0.0000
$X1^2$	−500676.7	76550.27	−6.540496	0.0000
X2	6805.549	5510.897	1.234926	0.2177
$X2^2$	−34370.58	44394.39	−0.774210	0.4393
QYS	0.114575	0.048120	2.381026	0.0178
TRQD	29.45882	11.22075	2.625388	0.0090

the coefficients of *X2* and $X2^2$ are not significant, but in terms of direction, there is also an inverted U-shaped relationship between the intensity of inward and the innovation performance. Under the combination of the intensity of outward and inward point, the influence of former on the innovation performance is more obvious, and both have inverted U-shaped relationship with innovation performance. In addition, the control variables have a significant positive impact on innovation performance.

4 Conclusion and Discussion

The overall development of characteristic economy in Guangdong province is stable and orderly, the competition among specialized towns is more and more solid, and the network of competitive relationship in specialized towns has remarkable and stable small world effect. On the whole, the competition relationship among industries in Guangdong are relatively sparse, and there is great development space. Beijiao Town, Fengxi District, Guzhen Town, Dachong Town, Guxiang Town and Xinjin Street in ten years exerted greater competitive pressure to other specialized towns, with a more obvious competitive advantage. Fengtang Town, Dongfeng Town, Nantou Town and Hetang Town, which are more constrained in the development process and in a position of relative disadvantage, bore the competitive pressure exerted by other specialized towns in the past 10 years.

Whether under the individual action or the joint action, there is a significant inverted U-shaped relationship between the outward point intensity and the innovation performance of the specialized town. The influence of the inward point intensity on the innovation performance is not significant, but in the direction of the inverted U-type relationship. In terms of control variables, the intensity of public science and technology investment, the number of characteristic economic enterprises have a significant positive impact on innovation performance.

Therefore, some suggestions for the development of specialized town economy in Guangdong Province:

First, the establishment of specialized town communication platform. It will play the role of industries association to promote the exchange of resources and information, in particular to encourage the development of strong towns, such as Humen Town, Chencun Town, Dalang Town, Changping Town and Qingxi Town, taking the initiative to impart the experience of successful development and promote the relatively backward towns under the leading of strong economic towns, to achieve common development.

The second is to standardize the competitive behavior of specialized towns and formulate effective coordination mechanism. Standardize the competitive behavior of the towns with prominent competitive advantages such as Beijiao Town, Fengxi District, Guzhen Town, Dachong Town, Guxiang Town and Xinjin Street. Formulate effective coordination mechanism, quickly respond the phenomenon of excessive competition and vicious competition, and maintain the healthy development environment of Guangdong province's characteristic economy. Step up the guidance of unstable specialized towns, such as Genghe Town, Sanjiao Town and Zhanggang Town, play to the intermediary role of specialized towns such as Humen Town, Dalang Town and Chencun Town in the network.

Third, to assist in the development of relatively weak specialized towns for repositioning. In view of the actual situation of these towns, such as Fengtang Town, Dongfeng Town, Nantou Town and Hetang Town, government should assist these to reposition themselves in combination with local cultural traditions, resource and geographical advantages.

Fourth is to improve the intensity of public science and technology investment and guide the technological innovation of enterprises. Government should continuously provide adequate funds and resources for the innovative development of specialized towns with characteristic industries.

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Cluster Analysis of the Internet Industry Development in Different Regions of China Based on Improved *K-means* Algorithm

Jian Ma, Runtong Zhang, and Xiaomin Zhu

Abstract Although the rapid development of the network technique and the Internet economy, China's Internet industry has exposed many problems such as imbalanced trend among China's provinces. In this paper, we employ the concept and method of improved *K-means* algorithm to establish a clustering analysis model of Internet development level in various provinces of China based on the imbalance of Internet popularization in China's provinces, and analyze the shortcomings and causes of Internet development in each province in detail. Finally, we recommend the corresponding policy suggestions in view of addressing issues mentioned.

Keywords The Internet industry · *K-means* algorithm · Clustering analysis

1 Introduction

The Internet industry refers to engaging in Internet operation services, application services, information services, network products and a general term for the development and production of network information resources and other industries related to Internet research, education, and service.

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The development of China's Internet started in the late 1980s. The development process can be roughly divided into four stages: the initial exploration stage, the basic network construction stage, the content active network popularization stage, and the current network prosperity stage.

With the popularity of the Internet and the advancement of technology, various forms of network applications are constantly emerging, and the field of Internet applications is constantly expanding. Internet applications range from early information browsing and e-mail development to online entertainment, information acquisition, communication, business transactions, and government services.

With the development of the economy and the advancement of society, under the guidance of technological innovation, the Internet has penetrated into all aspects of social and economic life and is bringing profound, unimaginable and unexpected changes to human society. As of 2013, global Internet users exceeded 2.2 billion; according to the 33rd Internet report released by China Internet Network Information Center CNNIC, as of the end of 2016, the number of Internet users in China reached 731 million, ranking first in the world; Internet penetration rate reached 53.2%. However, as a developing country with a large poverty gap, the Internet penetration rate in some regions is still not high, and it is necessary to conduct a detailed analysis of the development level of the Internet industry in various provinces in China.

Liu believes that the Internet has a unique advantage for social science popularization. How to make full use of the Internet as a platform to play its role in the popularization of social sciences has become a major issue in adapting to the trend of the times and exploring new channels for popularization of social science [1]. Bao et al. believe that although the Internet penetration rate in China has exceeded the world average, due to low coverage, low tariffs, and information security, there are still gaps with developed countries, and there is still much room for development. Due to the high demand of users on the Internet, the popularity of the Internet in different categories of population in China is not the same [2]. Sun has quantitatively analyzed this in five aspects: gender, marriage, age, education level and industry [3]. Wang et al. judged the stage of Internet penetration in various provinces and cities, and based on the inter-provincial panel data from 2005 to 2016, conducted δ-convergence and β-convergence tests on Internet popularity [4]. Xue et al. use the method of principal component to construct an indicator system for traffic evaluation in various provinces in China [5].

Clustering analysis is an important part of data mining. The *K-means* clustering algorithm is a basic partitioning method in cluster analysis method, and it is also an unsupervised machine learning method. It has the advantages of high efficiency, easy understanding and implementation. At the same time, it can cluster a variety of data types and is widely used in many fields, such as applied mathematics, pattern recognition, image segmentation and bioengineering. In this paper, the machine learning algorithm is applied to the analysis of Internet penetration rate in various provinces of China, and the unsupervised learning method is adopted. Improved *K-means* cluster analysis is carried out on the Internet data of each province in 2016, and corresponding policy recommendations are given.

2 Improved *K-means* Clustering Analysis Model

2.1 Selection of Optimal K Value—Contour Coefficient Method

The core indicator of the method is the Contour Coefficient. The Contour coefficients of a sample point x_i are defined as follows:

$$S = \frac{b - a}{\max(a, b)} \tag{1}$$

where a is the average distance between Xi and other samples of the same cluster, called the degree of cohesion, and b is the average distance between x_i and all samples in the nearest cluster, called the degree of separation. And the definition of the most recent cluster is:

$$C_j = \arg\min_{c_k} \frac{1}{n} \sum_{p \in C_k} |p - x_i|^2 \tag{2}$$

where p is a sample in a cluster C_k. In fact, the average distance from all samples of x_i to a cluster is used to measure the distance from the point to the cluster, and then the cluster closest to x_i is selected as the nearest cluster.

After obtaining the contour coefficients of all the samples and then averaging, the contour coefficients are obtained. The average contour coefficient has a value range of $[-1, 1]$, and the closer the distance between the samples in the cluster, the farther the distance between the samples, the larger the average contour coefficient, and the better the clustering effect. Then, naturally, the k with the largest average contour coefficient is the optimal number of clusters.

2.2 K-means Algorithm Model

The *K-means* algorithm takes distance as the standard for the measure of similarity between data objects, usually using the Euclidean distance to calculate the distance between data objects.

Euclidean distance calculation formula:

$$dist(x_i, x_j) = \sqrt{\sum_{d=1}^{D} (x_{i,d} - x_{j,d})^2} \tag{3}$$

Using Sum of the Squared Error (SSE) as the objective function of clustering, defined as J. Where D represents the number of attributes of the data object. In the clustering process of *K-means* algorithm, each iteration, the corresponding cluster center needs to be recalculated (updated): in the corresponding cluster, the mean of all data objects is the cluster center of the cluster after the update. The center of the cluster that defines the kth cluster is Center k, and the cluster center is updated as follows:

$$Center_k = \frac{1}{C_k} \sum_{x_i \in C_k} x_i \tag{4}$$

where K represents the number of clusters. When the difference between two iterations J is less than a certain threshold, that is, $\Delta J < \delta$, the iteration is terminated, and the obtained cluster is the final clustering result.

$$J = \sum_{k=1}^{K} \sum_{x_i \in C_k} dist(x_i, Center_k) \tag{5}$$

$$\begin{aligned} \frac{\partial}{\partial c_k} \mathrm{J} &= \frac{\partial}{\partial c_k} \sum_{i=1}^{K} \sum_{x \in C_i} (c_i - x)^2 \\ &= \sum_{i=1}^{K} \sum_{x \in C_i} \frac{\partial}{\partial c_k} (c_i - x)^2 \\ &= \sum_{x \in C_i} 2(c_i - x) = 0 \end{aligned} \tag{6}$$

$$\sum_{x \in C_k} 2(c_k - x_k) = 0 \Rightarrow m_k c_k = \sum_{x \in C_k} x_k \Rightarrow c_k = \frac{1}{m_k} \sum_{x \in C_k} x_k \tag{7}$$

The *K-means* algorithm can be described as:

- *Initialize K class cluster centers.*
- *Calculate the distance of each data object to the cluster center, and divide the data object into the clusters of the cluster center closest to it.*
- *Update the cluster center based on the resulting cluster.*
- *Continue to calculate the distance of each data object to the cluster center, and divide the data object into clusters in the cluster center closest to it.*
- *Continue to update the cluster center based on the resulting cluster.*
- *Iterating until the maximum number of iterations T is reached, or the difference between two iterations J is less than a certain threshold, the iteration is terminated, and the final clustering result is obtained.*

The detailed process of the algorithm is described as Fig. 1.

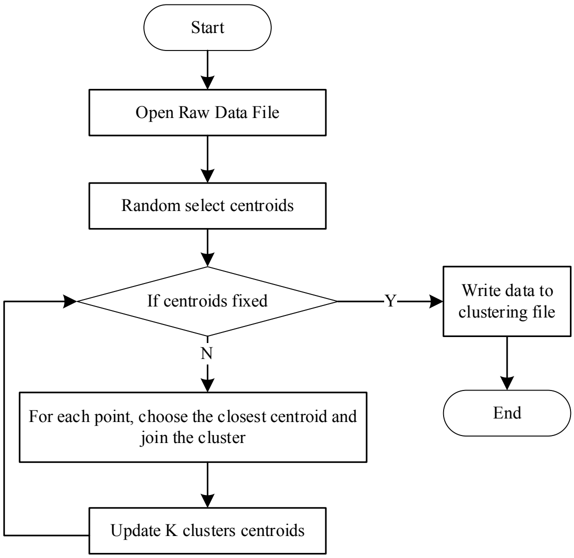

Fig. 1 *K-means* clustering algorithm flow chart

2.3 K-means++ Algorithm Model

- *K-means++ algorithm is an improvement of k means algorithm. The basic idea of K-means++ algorithm to select initial seeds is that the distance between the initial cluster centers should be as far as possible.*
- *Randomly select a point from the set of input data points as the first cluster center.*
- *For each point x in the dataset, calculate its distance D(x) from the nearest cluster center (referring to the selected cluster center).*
- *Select a new data point as the new cluster center. The principle of selection is: the point where D(x) is larger, the probability of being selected as the cluster center is larger.*
- *Repeat 2 and 3 until k cluster centers are selected.*

$$R\text{andom} = \text{sum}(\text{D}(\text{x}))^{*} \tag{8}$$

Compared with the traditional algorithm, the improved algorithm has better stability, higher computational efficiency and lower time complexity.

3 Analysis Process

3.1 Constructing the Indicator System of Internet Development Level in Each Province

It is very important to select the evaluation index in the evaluation of the Internet development level in a region. Based on the principles of system, comprehensiveness, effectiveness and data availability, we select indicators to build an index system of Internet development level analysis, a total of 5 indicators are selected. Those are *V1* Number of Internet users (10,000 people), *V2* Number of domain names (10,000), *V3* Internet dial-up users (10,000 households), *V4* Urban broadband access users (10,000 households) and *V5* Rural broadband access users (10,000 households).

3.2 Sample Data Source

According to the evaluation index system of Internet development level constructed above, the samples of 31 provinces and regions in the mainland of China except Hongkong, Taiwan and Macao are selected. The data in this article are mainly from the Chinese Statistical Yearbook 2017.

3.3 Results

In order to remove the influence of the population base, the four variables outside *V2* are replaced by the ratio of the indicator value to the total population of the region. The correlation coefficient matrix of each variable is shown in Fig. 2.

There is no correlation between the four factors selected in the clustering process, which can eliminate the phenomenon that the factors are correlated and the result is distorted.

Then, the contour coefficient method is used to select the optimal K value. When the K value is selected, the data is first normalized to the four factors, and then the K is evaluated. Since the general K is not too large, the traversal K is 3 to 8. Since *K-means* has a certain randomness, it does not converge to the global minimum every time. Therefore, for each k value, it is repeated 30 times, and the contour coefficients are calculated and finally averaged as the final evaluation criterion. The optimal K value is shown in the Fig. 3.

The results show that when K is 3, the average contour coefficient is much larger than other values.

Table 1 shows the center vectors for each category. And the clustering results are shown in Table 2 and Fig. 4.

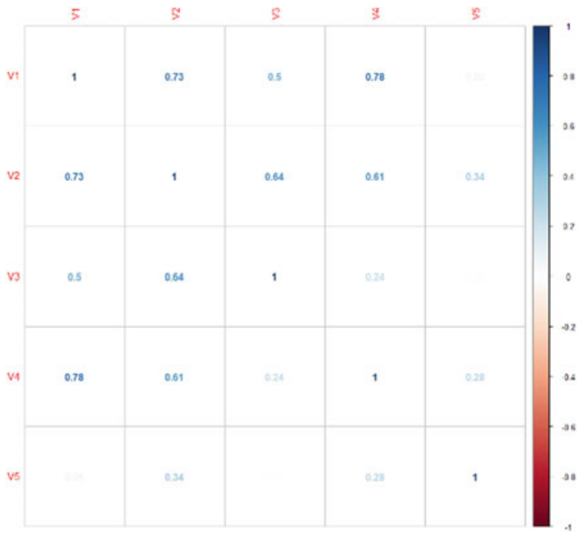

Fig. 2 Correlation coefficient matrix

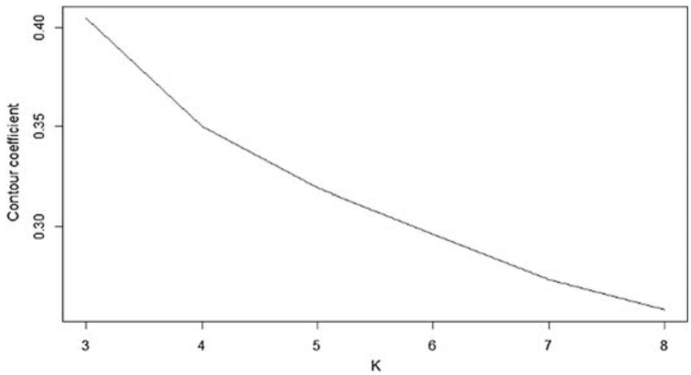

Fig. 3 Contour coefficient and *k* relationship diagram

Table 1 Clustering mean

Category	Internet penetration rate	Number of domain names	Internet dialup user ratio	Urban broadband access users	Rural broadband access users	Quantity
1	0.795	570.633	0.0101	0.2123	0.0648	3
2	0.558	191.101	0.0016	0.1979	0.0652	7
3	0.526	33.664	0.0016	0.1477	0.0378	21

Table 2 Provincial cluster

Area	Category	Area	Category	Area	Category
Beijing	1	Hebei	3	Chongqing	3
Fujian	1	Shanxi	3	Guizhou	3
Guangdong	1	Inner Mongolia	3	Yunnan	3
Shanghai	2	Liaoning	3	Tibet	3
Jiangsu	2	Jilin	3	Shaanxi	3
Zhejiang	2	Heilongjiang	3	Gansu	3
Shandong	2	Anhui	3	Qinghai	3
Henan	2	Jiangxi	3	Ningxia	3
Hunan	2	Hubei	3	Xinjiang	3
Sichuan	2	Guangxi	3		
Tianjin	3	Hainan	3		

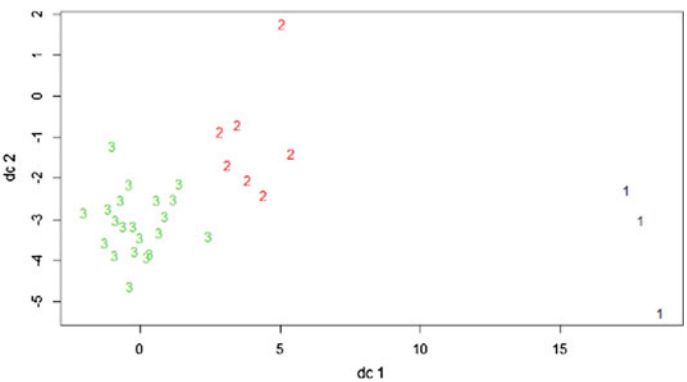

Fig. 4 Two-dimensional clustering map

Figure 4 shows the cluster analysis of each category in a two-dimensional space. It can be seen that the categories 2 and 3 have few differences, but they are very different from category 1.

It can be seen from Table 1 that the Internet penetration rate and domain name number of Category 1 are significantly higher than the other two categories. It can be seen that the overall development level of the Internet in the three regions of Category 1 is a leading level in China. Category 2 represents the level of China's medium Internet development, except that the above two indicators lag behind Category 1. The broadband penetration rate of cities and villages is not behind. It can be seen that among the seven cities in category 2, the popularity of the Internet has reached a leading level, but there is still room for improvement in the commercial application of the Internet. There are 21 provinces in category 3, accounting for two-thirds of the provinces in China. The overall penetration rate of these regions and the popularity of urban broadband users have reached a medium level. However, the network access in the countryside is very backward, and the commercial application of the Internet is far below the medium level.

According to the specific province categories in Table 2, we find that the provinces in Category 3 contain almost all the western regions, while in Category 1, Beijing, Guangdong and Fujian are the most developed regions in China's domestic economy. It can be seen that the level of development of the Internet also reflects the overall economic level. In addition, Shanghai is the top two cities in China, but in the cluster, it is classified as the second file. The detailed data found that the Internet penetration rate in Shanghai is slightly lower than that in Beijing, but the number of domain names is much lower than Beijing. It can be seen that companies in Shanghai do not focus on the application of the Internet.

4 Discussion

4.1 Lag Development of the Internet in Western China

The backwardness of the economic level in the western region has led to the lag of the development of the Internet. The central cities such as Chongqing have advantages such as strong traditional industrial base, rich population resources and superior geographical position, but they also generally face narrow development space and lack of natural resources, to realize the development of small space, developing the Internet industry is an inevitable choice for the development strategy of the central city of the western city. It is possible to support these cities with better economic bases to fully popularize the Internet and play an overall leading role in the western region. In addition, a major reason for the low rural penetration rate is that there are fewer new types of professional farmers in the western region who have culture, management, and technology. For this reason, cultural cultivation is needed. Only with a large number of new professional farmers who have culture, management and technology, the "Internet +" agriculture will be implemented.

The specific countermeasures are as follows [6]:

- Scientific planning and rational layout
- Well-equipped and powerful science and Technology Park
- School-enterprise cooperation and innovative services
- Policy and system support, necessary environmental and financial security.

4.2 The Internet Industry Development Gap Between Shanghai and Beijing

In response to this problem, we analyze the gap in Internet development between Shanghai and Beijing. In the history of China's Internet development, Shanghai once took the leading position. Before 2010, Shanghai was the capital of online games in China. From the perspective of the current scale of Internet companies, the giants in Beijing are everywhere, whereas, in Shanghai, it is smaller market scale and performed sophisticated. Behind the scale difference is the gap between the Internet talent pools in the two places. The stabilizing and balanced aspect of Shanghai culture has limited more top talents from the top 500 office buildings to the basement startups. There are more idealistic colors in Beijing's urban culture. There are a lot of "Northern drifters" who do not have Beijing registered residence, and they are longing for "Poetry and Distance". Every brightly lit office building in Zhongguancun, Wangjing, and Shangdi is a soulful, imaginative and ambitious soul. Secondly, the Shanghai government's response may act too slow, and the support for the Internet companies is not sufficient in policies. Shanghai has not existed as a large platform for the Internet companies for a long time, so it is difficult to obtain the talent agglomeration effect. Consequently, no talents, no active atmosphere, and no development in this area.

In 2015, the State Council passed the "Internet +" Action Guidance Opinion, which clarified the promotion of "Internet +", promoted entrepreneurial innovation, collaborative manufacturing, modern agriculture, smart energy, inclusive finance, public services, efficient logistics, e-commerce, Convenient transportation, green ecology, artificial intelligence and other key areas of development that can form a new industry model, and identify relevant support measures. Shanghai should keep up with the situation and use policy support to make up for the shortcomings in the Internet industry [7].

The specific countermeasures could be concluded and listed as follow:

- To adopt a top-down design and system implementation related support policies;
- To focus on key areas and cultivate leading enterprises in the Internet economy;
- To develop industrial internet with the help of industrial capabilities and traditional industry advantages;
- To focus on the construction of science and technology innovation center, vigorously implementing industrial basic technology and model innovation;
- Attracting and cultivating industry talents and strengthen industrial intelligence construction.

5 Conclusion

In this paper, the improved *K-means* algorithm is used to cluster the Internet index data of various provinces in China, and all provinces are divided into three categories. It also analyzes the characteristics of each category, which leads to the shortage of China's Internet development, and analyzes the problems of Internet penetration rate in the western rural areas and the underdeveloped Internet industry in Shanghai. Finally, some policy recommendations are given. Further research can provide more detailed data for in-depth analysis of the Internet penetration in rural areas in western China.

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Financial Agglomeration and Regional Economic Development: Double Threshold Research Based on Spillover Effect and Boundary Effect

Jiaqi Yuan

Abstract Financial agglomeration affects regional economic development by stimulating innovation to generate spillover effects. At the same time, the boundaries of the spillover process cannot be ignored because of the contractual and intensive nature of the financial industry itself. Based on the consideration of the spillover effect of agglomeration and the boundary effect of diffusion, this paper studies the double threshold of the impact of financial agglomeration on regional economic development in order to improve the related research of regional economy. Firstly, the paper uses the factor analysis method to measure the level of financial agglomeration. Then, the paper uses the panel data of 30 provinces from 2001 to 2015 to test the double threshold of financial agglomeration affecting regional economic development. It is concluded that with the increase of the level of financial agglomeration, it has played a leading role in promoting regional economic development, and the role of promotion has gradually increased. Therefore, maintaining a certain level of financial agglomeration is conducive to the stable development of the regional economy.

Keywords Financial agglomeration · Regional economic development · Spillover effect · Boundary effect · Double threshold model

1 Introduction

The deepening of financial marketization reform has made the allocation of financial resources more and more unbalanced. The phenomenon of financial agglomeration has become more and more obvious. Financial agglomeration can effectively reduce transaction costs, improve the efficiency of cross-regional allocation of financial resources [1, 2]. At the same time, it can share infrastructure in the agglomeration area, realize economies of scale [3–5], and generate spatial spillover effects of economies of scale [6], at last promote regional economic development [7, 8].

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The financial industry has a low cost of information acquisition. The development of Internet technology has enabled financial functions to gradually overcome the limitations of geospatial space. The low cost and efficiency of financial activities do not change with the increase of geographical distance. This form is called the end of geography. Due to the contractual and intensive characteristics of nonstandardized information and financial industry, certain regional boundaries have emerged in financial activities [9]. But the role of financial agglomeration in promoting regional economic development also has boundaries. Existing research pays more attention to the impact of regional economic development due to the spatial spillover of financial agglomeration. Li et al. [8] found that China's financial agglomeration has spatial correlation and certain radiation ability, but it is not strongly affected by China's administrative system. Sun and Wang [10] studied the spatial spillover effect of financial agglomeration based on the data of the five northwestern provinces, and believed that the government's macroeconomic policy support is conducive to the role of spillovers. Li and Wang [6] studied the role of financial human capital, financial agglomeration scale and financial output density in promoting urban economic growth from the perspective of spatial spillover. The spillover effect of financial agglomeration can not only promote regional economic development, but also promote industrial upgrading and improve industrial efficiency [9]. Although there is no shortage of research on the spillover effect of financial agglomeration in academic circles, it ignores the boundary of spillover effect. Although the literature mentions the boundary effect of financial activities itself, it has not been included in the impact on regional economy. Due to the difference in the level of financial agglomeration in different cities, the initial spillover effect is different, and as the spatial distance increases, the spillover effect will gradually weaken. Therefore, there are both spillover effects and boundary effects in financial agglomeration. Based on the consideration of the spillover effect of agglomeration and the boundary effect of diffusion, the paper studies the impact of financial agglomeration on regional economic development, which is divided into the following sub-goals: (1) How does the technology spillover effect of financial agglomeration and the boundary effect of proliferation affect the development of regional economy? What is its internal theoretical mechanism? (2) Under the premise of considering the technology spillover effect of financial agglomeration and the boundary effect of diffusion, is there any inflection point in the impact of financial agglomeration on regional economy?

The paper has the following two innovations:

(1) Perspective innovation. The existing research on the role of financial agglomeration in regional economic development mostly studies the regional economic impact of financial agglomeration from the perspective of spatial spillover, ignoring the boundary characteristics of the financial industry itself. This paper considers the spillover effect and the boundary effect to study the regional economic impact of financial agglomeration, and comprehensively considers the effect of financial agglomeration. In theory, it has improved relevant research on regional economic development, and in fact provides relevant policy guidance for regional economic development.

(2) Method innovation. It is assumed that the whole economy is in a state of constant returns to scale in the previous study of financial agglomeration literature. However, the agglomeration problem studied has its own characteristics of economies of scale. This characteristic will lead to an increase in the scale of returns. So the scale will be adopted. The assumption that the pay is constant will make the theoretical mechanism of the research problem inconsistent with the empirical model. In this paper, the traditional C-D production function is improved to adapt to the assumption of increasing returns to scale, avoiding the problem with inconsistencies in theory and experience in previous studies. It can also make the research more rigorous.

2 Theoretical Analysis of the Influence of Financial Agglomeration on Regional Economic Development

Since financial agglomeration has both spillover effects and boundary effects, the analysis of its effects on the regional economy should combine these two effects.

2.1 Spillover Effect of Financial Agglomeration

In the early stage of financial agglomeration, the spillover effect is more obvious. The spillover effect of financial agglomeration is mainly reflected in the spatial spillover effect of technology and knowledge generated by economies of scale. Financial agglomeration enables regional financial activities to be concentrated. In the process of agglomeration, scale effects will be generated, the cost of technological innovation will be reduced, the willingness of technological innovation will be enhanced, and technological innovation will be promoted. As innovation activities continue, more new technologies are widely used in production and life. And innovation knowledge is also rapidly circulating in the agglomeration area. Financial activities have spilled new technologies into other regions through the extensive nature of their clients. Knowledge has also accompanied the outward flow of technology to promote the economic development of these regions.

In addition, the main activities of the financial industry involve investment and financing and credit. Agglomeration accelerates the flow of information between financial institutions, reduces information barriers between financial institutions, and allows information to be fully circulated, reducing the degree of information asymmetry. For financial industry, information is a very important input. Reducing the degree of information asymmetry and accelerating the speed of information flow are conducive to improving the efficiency of the financial industry. The efficiency of financial activities in a region will overflow into other regions through the flow of capital. The flow and overflow of such efficient capital can effectively promote the development of capital markets in the surrounding areas. It plays a role in promoting regional economic development. Based on this, the paper gets hypothesis 1.

Hypothesis 1: With the gradual increase of the level of financial agglomeration, the role of financial agglomeration in promoting regional economic development has gradually increased.

2.2 Boundary Effect of Financial Agglomeration

Financial gatherings generate spillover effects and promote regional economic development. But the spillover effect is not endless. The boundary effect of financial agglomeration will hinder the impact of spillover effects to a certain extent. With the rise of financial agglomeration levels, the effect is becoming more and more obvious. The financial industry is different from other industries in that it is mainly subject to capital transactions and has strict contractual nature and intensive characteristics, so it is greatly affected by spatial distance. The contractual nature means that when a deposit and loan business is completed, a contract is required to complete the contract required to complete the contract, which means that the contract and the performance contract must be in the same place. As the level of financial agglomeration increases, the requirements for the "co-location" of such compliance are getting higher and higher. From the perspective of space, the scope of services for financial activities will be reduced. Therefore, if the spatial distance increases, the difficulty of signing and completing the contract at the same place will gradually increase, which will hinder the outward spread of the financial agglomeration results. The intensive nature means that intensive financial institutions can reduce information costs, increase the speed of information flow, and improve the efficiency of capital operations. With the increase of the level of financial agglomeration, the intensive nature of financial activities makes the spatial distribution of financial institutions not spread, and the closeness of the financial institutions within the financial agglomeration is increasing, which will weaken the agglomeration. The connection between the center and the outside area. The contractual and intensive characteristics of the financial industry together lead to the financial agglomeration showing a weaker promotion effect on the regional economic development as the level of financial agglomeration rises. When the concentration level reaches a certain level, financial agglomeration will inhibit regional economic development. Based on this, the paper gets hypothesis 2.

Hypothesis 2: When the level of financial agglomeration reaches a certain threshold, as the level of financial agglomeration rises, it has a depressing effect on regional economic development.

The above two effects can be represented by Fig. 1.

Since financial agglomeration has both spillover effects and boundary effects, when the level of financial agglomeration is gradually increased, its impact on regional economic growth plays a role of promoting and then suppressing.

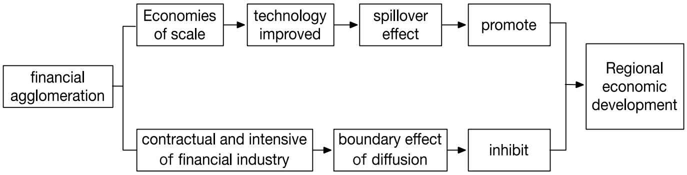


Fig. 1 The theoretical mechanism of financial agglomeration affecting regional economic development

3 Measurement of Financial Agglomeration

The level of financial agglomeration refers to the degree of concentration of a regional financial industry. The gatherings have an impact on the surrounding areas due to their externalities. The measurement methods for the level of financial agglomeration are diverse.

3.1 Variable Selection and Data Source

The measurement methods of financial agglomeration levels in the existing research can be divided into two methods: single index method and comprehensive index method. Single indicator refers to the measurement of regional financial agglomeration level with a certain indicator, specifically location entropy [11, 14], spatial Gini Coefficient, HI Index, industry concentration [15]. The indicators make the calculation of indicators relatively simple, but it is difficult to comprehensively reflect the concentration of financial industry in a region. Therefore, many scholars use the comprehensive indicator method to study financial agglomeration. The comprehensive index refers to the comprehensive representation of the level of financial agglomeration through multiple indicators. It is used in the current study are mainly divided into two types. One is to use several indicators at the same time to indicate the level of financial agglomeration. Sun and Wang [10] use the location entropy coefficient, financial scale, deposit-loan ratio and the product of the three together represent financial agglomeration to study its spatial spillover effect on regional economic growth. The other is to comprehensively express the level of financial agglomeration by establishing an indicator system, many scholars Relevant researches. Ding et al. [15], Yang [2] constructed a rating system for financial agglomeration from the perspective of the financial industry itself. Liang [16], Hu and Yang's Research [17] have been carried out from the perspective of macro motivation. However, the classification of these studies is too general to lack the indicators of economic impact of financial agglomeration. Ru et al. [18] have established urban financial agglomeration level measurement indicators from four aspects: financial background, financial scale, financial density and financial depth. The system, which comprehensively measures the level of financial agglomeration from the perspective of financial activities and it's economic impact. It can make up for the shortcomings of previous research. Therefore, this paper draws on its indicator system to measure the level of financial agglomeration. Among them, the financial development background reflects the overall economic scale and development level of the city. The size of the financial sector reflects the volume of activities in the financial industry. The density of financial activities is examined from the level of per capita financial activities and the density of regional financial activities. The depth of finance, that is, the level of service activity, reflects the degree of urban economic monetization and capital activity (Table 1).

Table 1 The indicator system of regional financial agglomeration level

Factor layer	Indicator layer	Measure
Financial environment	Total economic activity	GDP
	The level of economic development	Per capita GDP
Financial scale	Financial institution deposit scale	Balance of various deposits of financial institutions at the end of the year
	Financial institution loan scale	Balance of various loans of financial institutions at the end of the year
	Resident savings scale	Balance of urban and rural residents' savings at the end of the year
	Industry practitioner size	Total number of employees in the financial industry
Financial strength	Per capita financial development level	Balance of deposits and loans of financial institutions at the end of the year/total population at the end of the year
Financial depth	Financial activity density	Balance of deposits and loans of financial institutions at the end of the year/land area of urban jurisdiction
	Financial service activity	Balance of deposits and loans of financial institutions at the end of the year/regional GDP

[a]The data required for the calculation of the above indicators are derived from the 1995 to 2016 China Urban Statistical Yearbook and the China Economic and Social Development Statistics Database

3.2 Factor Analysis

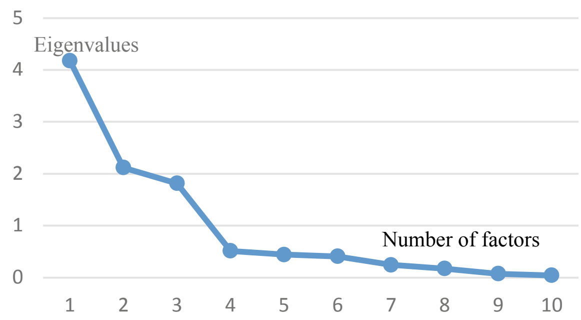
This paper uses factor analysis to measure the index system of regional financial agglomeration level. Before the factor analysis, each variable should be unitized first, and then the independence between the variables should be tested. The test results are shown in Table 2. The coefficient of KMO test and Bartlett sphericity test is 0.778, and the test P value is 0.000 less than 0.05. It can be considered that each variable is independent of each other to some extent, which is in line with the premise of factor analysis.

Figure 2 shows that when the number of factors is greater than 4, the trend of the factor eigenvalue tends to be flat. So the final number of factors is 4. At the same time, in order to better name the extracted factors, the maximum variance method is used to rotate the factors. The rotated factors are consistent with the structure shown in Table 1. Finally, the weights of each factor layer and indicator layer are established, and the weights of the income and the weight of each factor are used to calculate the financial agglomeration level of each province over the years.

Table 2 KMO and Bartlett sphericity test

KMO sampling coefficient		0.778
Bartlett sphericity test	*Approximate chi square*	3129.653
	Degree of freedom	36
	Significant	0.000

Fig. 2 Factor gravel map



4 An Empirical Analysis of the Impact of Financial Agglomeration on Regional Economic Development

4.1 Benchmark Model

This paper is based on the *C-D* production function. The specific model is shown as (1).

$$GDP_{it} = A_{it}^{\gamma} K_{it}^{\alpha} L_{it}^{\beta} \tag{1}$$

As financial gatherings promote industrial structure upgrading through innovation, and promote regional economic growth through spillover effects and industrial transfer, the core of the impact of agglomeration is the spillover effect of innovation. Therefore, A (technology) in C-D production function is regarded as financial gathering. In the previous studies, it is assumed that the scale returns are the same. But the externalities of agglomeration have the characteristics of increasing returns to scale. Therefore, this paper modifies the model as (2):

$$GDP_{it} = A_{it}^{\gamma_0+\gamma_1 X} K_{it}^{\alpha_0+\alpha_1 X} L_{it}^{\beta_0+\beta_1 X} e_{it}^{\delta_0+\delta_1 X} \tag{2}$$

where A represents the level of financial agglomeration, K represents fixed asset investment, and L represents the number of laborers. Correlation analysis shows that the Pearson correlation coefficient and the Spearman correlation coefficient of LnL and LnK are 0.433 and 0.683, respectively, and their correlations are significant at the significant level of 1%, so LnL and LnK have strong correlation. The data show that there are 14 million people in China's cities and towns to be employed, and there are 150 million surplus laborers in the rural areas, which have huge productivity. If the capital investment increases, a large number of jobs will be created, thus increasing labor input. Therefore, there is a strong relationship between capital and labor. Alternative, it can be argued that capital is the main driver of China's economic growth. And the increase in labor input is due to capital accumulation. So the model can be simplified as (3):

$$GDP_{it} = A_{it}^{\gamma_0+\gamma_1 X} K_{it}^{\alpha_0+\alpha_1 X} e_{it}^{\delta_0+\delta_1 X} \tag{3}$$

Logarithmic linearization of the model:

$$\begin{aligned} LnGDP_{it} = \delta_0 + (\gamma_0 + \gamma_1 X) LnA_{it} \\ + (\alpha_0 + \alpha_1 X) LnK_{it} + \delta_1 X \end{aligned} \tag{4}$$

where X represents the variable that affects the scale of financial agglomeration and the scale of investment. The index selected in this paper is the financing scale, which is represented by the sum of the balance of deposits and loans of financial institutions at the end of the year divided by the total investment of fixed assets at the end of the year.

4.2 Threshold Model

Because of the spillover effect and boundary effect of financial agglomeration, the effects of these two effects are opposite but interact with each other, so that there is a "threshold effect" under the dual influence of financial agglomeration. Therefore, this paper adopts the level of financial agglomeration. For the object of the threshold test, refer to Hansen [19] for the setting of the model. The specific model is shown as (5):

$$\begin{aligned} LnGDP_{it} = {} & \delta_0 + (\gamma_0 + \gamma_1 X) LnA_{it} \cdot I(LnA_{it} \leq \gamma) \\ & + \left(\gamma_0' + \gamma_1' X\right) LnA_{it} \cdot I(LnA_{it} > \gamma) \\ & + (\alpha_0 + \alpha_1 X) LnK_{it} + \delta_1 X \end{aligned} \tag{5}$$

where i is the province, t is the year, LnA_{it} is the threshold variable; γ is the specific threshold; $I(LnA_{it} \leq \gamma)$ and $I(LnA_{it} > \gamma)$ are the explanatory functions, δ_0, γ_0, γ_1, γ_0', γ_1', α_0, α_1, δ_1 are the estimated parameters respectively.

Considering the lag effect of capital investment, the capital investment of the year will have an impact on the economic growth in the next few years. Therefore, the lag term of LnK_{it} and $XLnK_{it}$ is added to the model. The specific lag order is determined by the threshold estimation. The model is shown as (6):

$$\begin{aligned} LnGDP_{it} = {} & \delta_0 + (\gamma_0 + \gamma_1 X) LnA_{it} \cdot I(LnA_{it} \leq \gamma) \\ & + \left(\gamma_0' + \gamma_1' X\right) LnA_{it} \cdot I(LnA_{it} > \gamma) + (\alpha_0 + \alpha_1 X) LnK_{it} \\ & + (\alpha_0 + \alpha_1 X) LnK_{it-1} + \cdots + \delta_1 X \end{aligned} \tag{6}$$

In order to ensure the availability of data, this paper uses data from 30 provinces (excluding Tibet) in China from 2001 to 2015. The sample data are from the 2002 to 2016 China Urban Statistical Yearbook, and the value of LnA_{it} is calculated from the previous article.

4.3 Results

Since the specific number of threshold values cannot be determined, the test is performed under the assumption that there are one, two and three threshold values. In this paper, LnA_{it} is selected as the threshold variable, and $XLnA_{it}$ is the core explanatory variable, indicating that the finance is under different financing scales. The level of agglomeration and the results of the threshold test were obtained using Stata 14.1 software. The calculation results are shown in Table 3. The result of the single threshold test is that there is a significant threshold. The result of the double threshold test is that there are two threshold values, negating the result of the single threshold. The result of the triple threshold test cannot effectively reject the original of the double threshold. Assume, therefore, that the optimal threshold is 2. Based on this, the paper uses the double threshold model as the research model.

The results of the threshold test show that there are two threshold values. The estimated values of the two threshold values and their confidence intervals are shown in Table 4 and Fig. 3. The red horizontal dashed line in Fig. 3 indicates a significant level of 95%. When the two threshold values are within their confidence intervals, the image is below the red dotted line.

Parameter estimation can be performed after the threshold value is determined. In this paper, the double threshold model and the linear fixed effect model are used for estimation. The robustness of the double threshold model is tested at the same time. The estimated results are shown in Table 5. It can be seen that the sign and magnitude of the explanatory variable coefficients of the double threshold model and the linear fixed effect model are basically the same. From the significant point of view, the coefficient of the double threshold model has a higher level of significance, indicating that the threshold model is used to describe the problem effectively.

After adding two thresholds, the coefficients of the three-stage core explanatory variables are significant at the significant levels of 1% and 10%, respectively, that is, the impact of financial agglomeration on regional economic development is at a threshold. When the financial agglomeration level is lower than −0.2643, financial

Table 3 Threshold effect test

Threshold variable	Hypothetical	Number of thresholds	F	P[a]
LnA_{it}	H0: liner model	One threshold	41.38**	0.050
	H1: one threshold			
	H0: one threshold	Two thresholds	70.54***	0.000
	H1: two thresholds			
	H0: two thresholds	Three thresholds	14.26	1.000
	H1: three thresholds			

[a]The P value is obtained by repeated sampling 100 times using the 'self-sampling method'. ***, **, * indicate a significant level of 1%, 5%, 10%

Table 4 Threshold estimates and confidence intervals

Threshold estimates		95% confidence intervals
The first threshold	−0.2643	[−0.2672, −0.2642]
The second threshold	−0.2319	[−0.2327, −0.2318]

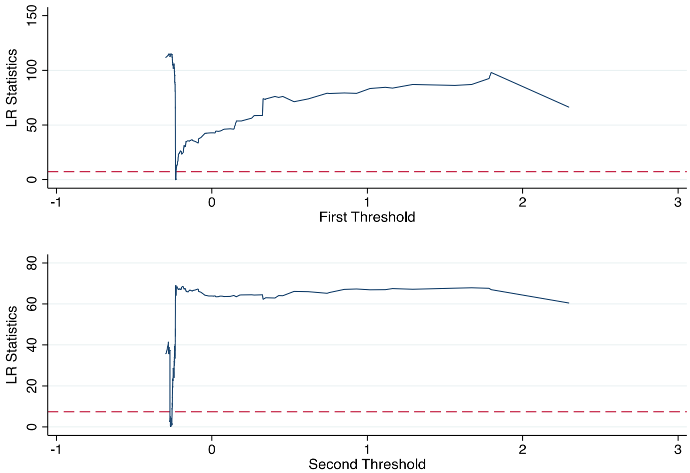


Fig. 3 Double threshold estimation and confidence interval of financial agglomeration level

Table 5 Threshold model estimation result

Variable	Double threshold model	Linear fixed effect model
δ_0	3.900853*** (4.40)	1.636727 (1.66)*
X	824.1288*** (5.40)	150.2041 (1.56)
LnK_{it-1}	0.3039838*** (6.06)	0.4206603*** (7.50)
LnA_{it}	0.4718194** (2.72)	0.4043345** (2.08)
$XLnA_{it} \cdot I$ $(LnA_{it} \leq -0.2643)$	1817.166*** (3.37)	–
$XLnA_{it} \cdot I$ $(-0.2643 < LnA_{it} \leq -0.2319)$	6260*** (10.18)	–
$XLnA_{it} \cdot I$ $(LnA_{it} > -0.2319)$	−359.7886* (−1.91)	–
$XLnA_{it}$	–	228.7203*** (3.61)

Remarks: t statistics in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

agglomeration has a positive effect on regional economic growth. However, due to the low level of agglomeration, the spillover effect is relatively small, so this promotion is not large. When the financial agglomeration level between −0.2643 and −0.2319, with the further increase of the level of financial agglomeration, the scale of financial agglomeration is getting larger and larger. So the promotion of regional economic development is also stronger, and the enhancement of this promotion exists.

The obvious jump indicates that the rise of the level of financial agglomeration will have a huge change in regional economic development. When the level of financial agglomeration further rises to more than -0.2319, the financial gathering has a negative impact on regional economic development, which is related to the assumption that there is a boundary effect is consistent.

Due to the existence of the financial agglomeration boundary effect, the impact of financial agglomeration on regional economic development has been "truncated". When the level of financial agglomeration is strong, it should have a stronger promotion effect on regional economic development. It also can be generated for further regions. The positive action, but the existence of the boundary effect makes the benefits of agglomeration difficult to spill out. The higher concentration means the higher dependence on the agglomeration center. So the stronger the level of financial agglomeration, the stronger the connection with the center The connection with the outside world is relatively weak. In addition, the original economic development gap between the regions makes it difficult for the local economic development level to adapt to the technological level of financial agglomeration spillover, which will hinder the development of the regional economy to a certain extent.

5 Conclusion

Technological advances arising from financial agglomeration will promote regional economic growth through spillover effects. At the same time, the boundaries of financial agglomeration cannot be ignored due to the contractual and intensive nature of the financial industry itself. The paper considers the spillover effect and boundary effect of agglomeration, and believes that the impact of financial agglomeration on regional economic growth will have a threshold effect under the combined effect of the two effects. Using the national data of 30 provinces from 2001 to 2015, the factor analysis method was used to measure the level of financial agglomeration. Then the threshold effect of financial agglomeration was tested by the double threshold model. The conclusions were drawn: (1) Financial agglomeration There are double thresholds for the impact of economic growth; (2) The level of financial agglomeration of a certain scale can promote the regional economic growth; (3) The boundary effect of the impact of financial agglomeration on regional economic growth with the distance between the gathering center and the surrounding area. When the increase and increase, the boundary effect is strong, the gap between the financial agglomeration level and the level of economic development of the two places plays a decisive role in the relationship between financial agglomeration and regional economic development. Based on the above conclusions, the paper proposes the following recommendations:

For the area where the financial agglomeration center is located, reduce the administrative barriers to financial industry agglomeration, encourage financial industry innovation, simplify the complicated procedures for deposits and loans of financial institutions, and promote the realization of financial agglomeration of a certain scale.

Different policies should be adopted for regional economic development to encourage economic development in various regions. Specifically, it can appropriately reduce the economic growth rate of developed regions, increase the economic growth rate of relatively underdeveloped regions, and narrow the gap between the level of financial agglomeration and the level of economic development.

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The Impact of China's Structural Monetary Policy on Monetary Inflows into the Real Economy

Tongya Yang

Abstract At present, the entity economy in our country is weak, the investment yield declines and the real economy internal risks escalating problems show that in our country's current capital in the economic operation "to take off the real to virtual" trend. With the deepening of the process of "de-reality" of funds, the financing cost in China's real economy will gradually increase, which will cause the difficulty of financing and the risk of financial system are growing increasingly, and the difficulty of transformation and upgrading of the real economy will increase. This paper analyses that structural monetary policy changes market expectations through signaling, and verifies the impact of structural monetary policy on real economy through event studies. Finally, we put forward the following suggestions: firstly, we should differentiate the interest rate and quota of monetary policy according to the counterparty; secondly, we should improve the information disclosure of central bank when implementing monetary policy; finally, when implementing monetary policy, we should first adjust the open market operation, then the deposit reserve ratio, and finally the interest rate adjustment in the process.

Keywords Real economy · Event studies · Structural monetary policy

1 Introduction

China's economy is now entering a "new normal", which means the growth are from the past pursuit of quantitative to the pursuit of high-quality growth. This transformation also shows that China's future economic growth will depend more on the efficiency of capital operation than on the accumulation of quantity. However, at present, although the overall economic situation is stable, under the background of the current economic restructuring and industrial transformation and upgrading, the virtual economy can not serve the real economy well and lead to the imbalance

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of the relationship between themselves, and the hollowing of the real economy is becoming more and more prominent. Since the global financial crisis in 2008, the decline of economic growth in some emerging market countries and the sovereign debt crisis in Europe has cast a shadow on the global economy. In order to cope with the deterioration of the global economic and financial environment, countries began to actively seek structural monetary policy.

Signal channel refers that the central bank's positive impact on the price of financial assets by issuing information and taking certain measures to release signals to the market to enhance overall market confidence and reverse market expectations, and then reduce risk premiums and uncertainties within the financial system, thereby reducing the credit conditions of enterprises, increasing capital gains of enterprises and individuals, and ultimately reaching the target. To enhance the investment and consumption goals of the whole society. In recent years, with the extensive using of structured monetary policy, many scholars have found that the signal transmission of structured monetary policy in European and American countries has a significant impact on the financial indicators such as stock market prices, market interest rates, bond yields and real exchange rates. Due to the widespread existence of uncertainty and information asymmetry, a large number of decisions in financial markets are based on rational expectations [1, 2]. Therefore, the key to the role of monetary policy lies in its impact on market expectations, rather than its change in the current economic situation. During the economic depression, the central bank can boost market confidence and change market expectations by issuing announcements and taking measures to release signals to the market, thus reducing risk premiums and uncertainties in financial markets and reducing financing costs for enterprises and households [3–5]. Only when the central bank makes a credible commitment to keep monetary policy loose for a long time can key indicators such as long-term bond yields be significantly affected [6].

Our study is based on the starting point of monetary policy, from the perspective of structural monetary policy, merger of fiscal policy and financial instruments to guide the monetary flow into the real economy.

The following part is carried out in accordance with the following framework: The second part analyses the causes of the downturn of China's real economy by considering the existing research and combining with the current economic situation, and puts forward the internal causes of the economic slowdown and the reasons from the perspective of generalized virtual economy; the third part, based on the analysis of the above reasons, puts forward the conformity with China's real economy from the perspective of structural monetary policy. The fourth part considers the current monetary policy of our country and puts forward suggestions on the implementation of relevant policies. Finally, the fifth part of the article makes a summary of this study.

2 Reasons for the Decline of Real Economy Growth

In a stable market, the average return rate of dominant industries of social entities is higher than that of financial assets. At this time, in essence, some of the financial assets participate in the distribution of the economic value created by the real economy; while under the condition of market bubble, the rate of return on financial capital investment is obviously higher than that of the real industry, when financial capital takes the label of "financial services in the real economy". This behavior will not only occupy the capital of the real economy. Investment, or even because the return on financial assets is higher than that of the real industry, the industry investment needs to be dominated by financial transactions. This criterion has become one of the main reasons for the rapid expansion of financial capital and the financial bubble in recent years.

2.1 Internal Causes

In recent years, the average growth rate of M2 in China is about 17%, while the average annual growth rate of GDP and CPI is only about 9 and 3%. The growth rate of money supply M2 is much higher than that of economic growth (GDP) and price level (CPI). There is a significant deviation between money supply and economic growth. At present, the global economic growth rate is slowing down, while the domestic economy has entered the transition period. Although the inflation risk is not obvious in a short period of time, China's current financial industry can not serve the real economy very well. There is a disconnection between the two. At present, the domestic real economy is facing severe challenges such as increasing production costs, excess capacity and breaking of capital chain, which directly results in the decline of profits of all kinds of enterprises, especially the small and medium-sized enterprises in the low-end industrial chain, mainly manifested in the difficulty of obtaining funds, the lack of orders, the rising cost of labor force and raw materials, etc. The following figures show growth rates of M0, M1, M2 and GDP.

The gap between M1 and M2 can be regarded as an important tool to measure the amount of money in circulation. From Fig. 1, we can see that the gap between M1 and M2 has changed from negative to positive and the gap has decreased. We can see that the demand for cash for transactions and settlement has decreased, the activity of monetary funds has declined, and a large amount of money has not really entered the real economy.

(1) *The overall level of real economic profits:* Under the circumstance that financial services are increasingly divorced from the real industry, the outflow of productive capital is increasing while the investment of capital is decreasing. Finally, the real economy is flat, the financing ability of enterprises from the financial market is weakening, and the development expectation of enterprises in the real economy is declining. At the same time, due to the impact of the international

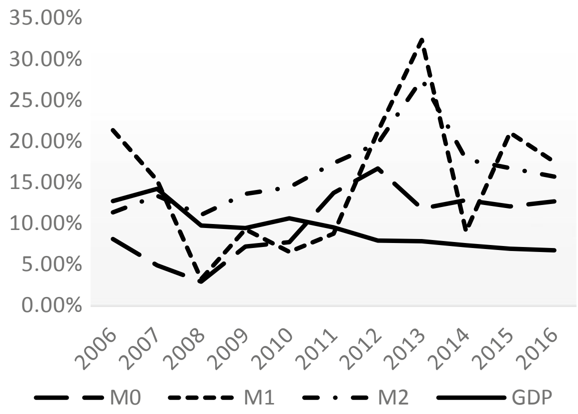

Fig. 1 Trend map of money supply and real economic growth in China since 2006

financial crisis, the economic downturn of large foreign economies has directly led to a sharp reduction in foreign trade orders of Chinese enterprises, and the expected increase in the main business income. In addition, the rising prices of domestic labor, land and raw materials, together with Vietnam, Thailand and other emerging countries in Southeast Asia by virtue of their own advantages to depress prices to seize orders in China, the external demand slump has gradually become the norm. From the point of view of domestic demand, although the retail sales of social commodities are growing steadily, the average contribution rate of consumption to GDP in China is only about 60%. Compared with the proportion of consumption to GDP in western developed countries, the average contribution rate of consumption in China is obviously low. From the perspective of household income, as of early 2017, reports show that China's wealth Gini coefficient is 0.73, much higher than the international warning line of 0.4. Gini coefficient indicates the degree of inequality, and the high Gini coefficient in China limits the development of domestic demand to a certain extent. At the same time, the bubble of the real estate industry is constantly increasing, the imperfection of the social security system and the low expectations of the residents will inhibit the growth of domestic demand to varying degrees.

(2) *Production factors:* Capital investment, technology input, various social resources, labor force, enterprise management and financing capabilities and other productive factors jointly promote the development of the real economy. However, the common squeeze of asset bubbles and inflation has led to the loss of a variety of factors in the development of the real economy, resulting in the hollowing of the real economy industry. On the one hand, the constraints of resource reduction lead to the increase of the cost of employing manpower and purchasing raw materials. Compared with the per capita wage of the real manufacturing industry, the per capita wage of the financial industry is not only higher than that of the real enterprises, but also rising rapidly in recent years. With the continuous use of factories, energy products have limited production

capacity in the natural environment, and the supply is reduced under the condition that demand remains unchanged or even expands. As the price of resource products rises, the investment cost of enterprises increases day by day.

2.2 Reasons for Economic Downturn Caused by Virtual Economy

(1) *Cost of Social Financing:* The increasing cost of social financing has become the most prominent reason why it is difficult for our country's capital to flow into the real economy. That is to say, the real economy has to pay a higher price to absorb the stock funds in the market than before. With the development of economy, although the sources of financing in real economy are becoming more and more extensive, the costs of different financing channels are different, and their rising rates are also different. According to the survey report of China's social financing cost index, the average cost of corporate social financing in China is 7.60%. Among them, the lowest average financing cost of bank acceptance draft is 5.19%; the highest average financing cost of small loan companies is 21.9%; the average financing cost of bank loans is 6.6%; the average financing cost of corporate bonds is 6.68%; the average financing cost of financing trust is 9.25%; the average financing cost of factoring services is 12.1%; the average financing cost of Internet finance is 21.0%; The average financing cost of lease is 10.7%, and the average financing cost of equity pledge of listed companies is 7.24%.

The reasons for the rising financing costs of real enterprises can be summarized from the following four aspects. Firstly, the process of interest rate marketization is deepening gradually, and the adjustment of bank customer loan structure leads to the rise of loan interest rate. In order to cope with the competition of interest rate marketization and absorb more deposits in time, major banks have to adopt the way of floating and rising deposit rate. At the same time, they have to design and develop some financial products pricing by market interest rate. At the same time, the trend of financial disintermediation of large enterprises in China is increasingly apparent. Banks begin to provide more loans for SMEs. Generally speaking, the credit of SMEs is lower than that of large enterprises, so the risk premium on credit is increased, which is ultimately reflected in the rise of bank credit interest rate. Secondly, the macroeconomic downturn has pushed up risk-free interest rates. Thirdly, the extension of financing chain, such as agency fee, trusteeship fee and commission fee, has increased the chain, leading to the increase of financing cost and ultimately reflected in the rise of interest rates.

(2) *Financing supervision:* Taking the United States as an example, in the 1980s, the crisis of the American Savings and Loan Association led to the collapse of a large number of small and medium-sized financial institutions. The reason for this phenomenon was that the American enterprises were in the process of financial

disintermediation and the lack of government supervision, which magnified the risk of assets and liabilities of the Savings and Loan Association. At present, through strengthening supervision of local financing platforms, off-balance-sheet financing of banks, private lending and other financing businesses, off-balance-sheet risk and credit risk have been initially controlled. However, in the critical period of economic growth slowing down and economic restructuring, some financing modes in China still exist such phenomena as rigid payment and lack of transparency. Therefore, it is necessary to strengthen financing supervision to further mitigate risks and prevent the phenomenon of continuous default caused by the rupture of the capital chain. If credit risk and off-balance-sheet risk can not be detected and solved in time by the regulatory authorities, it may affect the stability of economic and financial markets.

3 Data and Methodology

3.1 Signal Transmission Mechanism of China's Structural Monetary Policy

The mainstream view in society holds that when the transmission of traditional monetary policy is in trouble, structural monetary policy begins to be implemented. Its goal is to guide the flow of funds, especially to the real economy of small and medium-sized enterprises or some key industries, and then to open the transmission channel of monetary policy. In the process of implementing structural monetary policy, the transmission of signal channels is needed to ensure the effectiveness of monetary policy implementation.

At present, China's structural monetary policy has an impact on macro-economy mainly in three aspects: (1) According to the demand of economic growth in some regions or industries and the amount of assets held by banks themselves, the central bank provides short-term, medium-term and long-term liquidity currencies by using SLO, SLF, MLF and PLL monetary policies respectively to alleviate the increasing downward pressure of macro-economic growth on financial institutions. As a result, the liquidity is reduced, leading the financial sector to release liquidity to the entity enterprises in line with the current policy-oriented in China, so as to reduce financing costs and promote the investment and consumption capacity of enterprises and individuals; (2) In order to invest credit resources in key areas of development and weak links, the central bank directly reduces the financing of rural and small and medium-sized enterprises by implementing policies such as PSL and directed refinancing. At the same time, it can also achieve the purpose of supporting key strategic industries, thus promoting the economic system reform; (3) By implementing the policy of differential deposit reserve ratio, it can help to improve the liquidity of agricultural-related financial institutions and other commercial banks with a certain proportion of loans from agriculture, rural areas and small and micro enterprises, to expand the credit scale of financial institutions, and effectively guide the flow of funds into the real economy.

3.2 Estimation Models

Through the constant mean model of event study, this paper makes an empirical analysis of structural monetary policy events and SHIBOR interest rates in different periods as market indicators in order to draw a conclusion that most of the implementation of structural monetary policies have a significant impact on the decline of interest rates in the monetary market. At the same time, it is assumed that the return rate of the index is a constant in each event window:

$$E(r_{it}) = \mu_i \tag{1}$$

where μ_i is the average value of the index SHIBOR in one year before the event window:

$$\mu_i = \frac{1}{t_1 - t_0} \sum\nolimits_{t=t_0}^{t_1-3} r_{it} \tag{2}$$

Then, the abnormal return rate of event window is calculated by estimating normal return, and its cumulative value in event window is cumulative abnormal return (CAR).

$$CAR(t_1, t_2) = \sum\nolimits_{t=t_1-2}^{t_1+2} (R_{it} - \mu_i) \tag{3}$$

where r_{it} is estimated abnormal return, R_{it} is the real SHIBOR, $[t_0, t_1 - 1]$ is estimation window, $[t_1 - 2, t_1 + 2]$ is event window, because there may be information leakage before the event happens and other reasons have an impact on the market ahead of time, so the event window selection event occurs two days before to two days after the occurrence. Then, the significance test of cumulative abnormal return rate is carried out by double tail t test. The events in the Table 1 are selected from the Monetary Policy Events of the People's Bank of China.

In this paper, SHIBOR overnight, one week, two weeks, January, March, June, September and one year interest rates are selected as indicators of money market. The sample range is from November 3, 2013 to February 21, 2017. The data are from the People's Bank of China.

Based on the event study method, this paper analyses the impact of structural monetary policy signals on the excess return rate of money market in China. It is found that almost all structural monetary policy announcements bring about a significant decrease in the interest rate of money market. The following table reflects

Table 1 Summary of structural monetary policy events

Date	Event
November 6, 2014	The People's Bank of China issued the third quarter of 2014 monetary policy implementation report, which disclosed the following contents: on April 25, 2014, in order to implement the spirit of the 43rd Standing Meeting of the State Council, the People's Bank of China created mortgage supplementary loan (PSL) to provide long-term stable and cost-effective funding source for the development of financial support shanty reform. In September 2014, the People's Bank of China created the Medium-Term Lending Facility (MLF) to provide medium-term base currency for financial institutions that meet the requirements of macro-prudential management. The medium-term lending facilitation rate plays a role of medium-term policy interest rate and promotes the reduction of social financing costs
February 6, 2015	The People's Bank of China has issued the Notice on Developing Standing-by Lending Facilities for Branches throughout the country and the Notice on Issuing Guidelines on Relending and Standing-by Lending Facilities for Mortgages for the People's Bank of China (for Trial Implementation). On the basis of the trial operation of Standing-by Lending Facilities for Branches in 10 provinces (cities) in the previous period, it has promoted Standing-by-Standing Lending Facilities for Branches throughout the country and improved the Central Channels for Providing Liquidity Support to Small and Medium-sized Financial Institutions
February 6, 2016	The People's Bank of China issued the report on the implementation of monetary policy in the fourth quarter of 2015, which disclosed the following contents: In November, in order to explore the role of the upper limit of the interest rate corridor in exploring the standing lending and lending convenience rates of branches, the People's Bank of China decided to reduce the standing lending and lending convenience rates of branches appropriately in order to meet the requirements of macro-prudence, considering the liquidity situation at that time and the demand of monetary Methods The interest rates of overnight and 7-day financial institutions were 2.75% and 3.25% respectively
May 6, 2016	The People's Bank of China issued the first quarter of 2016 monetary policy implementation report, which disclosed the following contents: enriching the term structure of medium-term lending facilities, increasing the period from six months to three months, six months and one year, and gradually reducing interest rates to 2.75%, 2.85% and 3.0%, respectively. Medium-term lending facilitates the role of medium-term policy interest rates, guides financial institutions to reduce lending interest rates and social financing costs, and supports real economic growth
February 17, 2017	The People's Bank of China issued the fourth quarter of 2016 monetary policy implementation report, which disclosed the following contents: In January 2017, the People's Bank of China provided temporary flow for several large commercial banks with large cash investment volume through temporary liquidity facility (TLF) operation in order to guarantee the centralized demand formed by cash investment before the Spring Festival and promote the liquidity of the banking system and the smooth operation of the money market. The dynamic support can meet the temporary liquidity demand more effectively through the market-oriented mechanism

the impact of structural monetary policy announcements on the excess return on the money market. It can be seen that the expansion of structural monetary policy and the creation of TLF from 2015 to 2017 brought about a significant decline in SHIBOR interest rates (Table 2).

According to the above analysis, the impact of China's structural monetary policy on monetary policy is more significant. At the same time, most structural monetary policy announcements indicate that China's central bank will continue to implement loose monetary policy in the future to ensure reasonable liquidity in the short, medium and long term. At the same time, it will guide the market interest rate to reduce the cost of social financing and promote the real economy development.

However, with the passage of time, the greater the macroeconomic uncertainty, the more likely the central bank will change its policy accordingly. Therefore, the return on assets with long term interest rate is less affected by channel signals.

Table 2 Regression estimation results

Date	SHIBOR O/N	SHIBOR 1 W	SHIBOR 2 W	SHIBOR 1 M
2014/11/6	−230.60*** (0.000)	−77.94*** (0.000)	−77.56*** (0.000)	−47.85*** (0.000)
2015/2/6	38.27* (0.052)	−298.17*** (0.000)	−205.27*** (0.000)	−219.96*** (0.000)
2016/2/6	−264.42*** (0.001)	−265.55*** (0.000)	−243.29*** (0.003)	−213.29*** (0.004)
2016/5/6	−103.42*** (0.000)	−42.68*** (0.002)	−12.69*** (0.000)	−11.06*** (0.000)
2017/2/17	−461.68*** (0.000)	−413.01*** (0.000)	−398.68*** (0.000)	−344.15*** (0.000)
Date	SHIBOR 3 M	SHIBOR 6 M	SHIBOR 9 M	SHIBOR 1 Y
2014/11/6	25.47*** (0.000)	18.93*** (0.001)	15.61*** (0.000)	17.50*** (0.000)
2015/2/6	−165.03*** (0.000)	−99.98*** (0.000)	−56.27*** (0.000)	−3.45*** (0.004)
2016/2/6	−199.61*** (0.001)	−195.15*** (0.000)	−191.45*** (0.000)	−181.20*** (0.000)
2016/5/6	−6.25*** (0.000)	−4.17*** (0.002)	−10.57*** (0.000)	−3.91** (0.013)
2017/2/17	−317.04*** (0.000)	−181.95*** (0.000)	−64.52*** (0.000)	−39.79*** (0.000)

*The P value of double-tailed t test is in parentheses; ***, **, * means passing the test with significance level of 1%, 5% and 10%, respectively*

4 Conclusion

In the last chapter, we use event studies method to analyze the influence of signal transmission of structural monetary policy on the monetary market and the development of real economy in China from the perspective of structural monetary policy. At the same time, we point out the current restrictive factors. Empirical results show that the transmission of China's structural monetary policy in the monetary market is more obvious. Most of the structural monetary policies have led to the decline of the main interest rate indicators. Therefore, we can believe that structural monetary policy can promote the entry of money into the real economy. Based on the above analysis, this chapter gives the following suggestions:

Firstly, we should distinguish the interest rate and quota of monetary policy according to the counterparty. Currently, the liquidity policies of MLF and SLF implemented by the Central Bank of China over 7 days have not distinguished different counterparties in terms of monetary interest rates and quotas. Referring to the European Central Bank's TLTROs (long-term refinancing operation policy), the larger the amount of loans provided by financial institutions to residents and non-financial enterprises, the lower the long-term liquidity interest rate obtained through TLTRO. Through the improvement of this regulation, we can make the transmission of structural monetary policy more smoothly and better promote the flow of funds to the real economy sector.

Secondly, the central bank should enhance the degree of information disclosure in the implementation of monetary policy. At present, the information disclosure of the structural monetary policy of the Central Bank of China needs to be improved urgently. For example, the PSL and MFL policies were established in April and September 2014, respectively, but they were disclosed only when the central bank released the third quarter monetary policy implementation report in November of that year. If the information can not be disclosed to the society in time, it will have a negative impact on the effective transmission of monetary policy signal channels. Therefore, it is necessary for the central bank to strengthen the degree of information disclosure, but at the same time, it should be cautious about policy disclosure in order to prevent unnecessary fluctuations.

Thirdly, in the process of implementing monetary policy, I think we should first adjust the open market operation, then the deposit reserve ratio, and finally adjust the interest rate. Because the rise and fall of interest rate will lead to arbitrage, which will lead to the inflow or outflow of foreign funds in the form of hot money into our virtual economy. On the one hand, it will lead to meaningless loss of national income; on the other hand, the inflow of funds within the virtual economy weakens the effect of macro-control. At the same time, compared with negative interest rate countries, China's deposit reserve ratio is so high that the adjustment range of the reserve ratio is limited. Therefore, efforts should be made to control currency issuance, especially M2, regulate usury and reduce shadow banking space. In addition, we need to strictly control the influx of hot money. The imported funds can not directly enter the virtual economy, but should be combined with the real economy, promote the development of the real economy, improve the efficiency and quality of foreign investment, and then reduce the impact of hot money.

Finally, we should promote the marketization of interest rates. In the market-oriented financial environment, capital can flow freely and the efficiency of capital utilization is improved, which promotes the development of real economy. At present, China is still in the bank-dominated financial system. The flow of funds is mainly controlled by banks. Traditional finance has been monopolized for a long time. In order to make profits under the high interest rate difference between deposits and loans, on the one hand, the financing needs of the real economy represented by small and medium-sized enterprises can not be met, on the other hand, the savings rate of residents is high. Therefore, the traditional financial institutions represented by banks can not be well established. The dislocation of social capital allocation exists in the service of physical economy, and the low utilization of social capital inhibits the normal development of real economy. Therefore, to promote the process of interest rate marketization is the way we must choose at present. The structural problems of the economy essentially need to be reformed through the system. In the long run, the optimization of credit resources, the endogenous motive force of economic growth and the adjustment and upgrading of economic structure essentially require system reform, so that the whole economic market can play a decisive role in the allocation of resources. Therefore, the combination of various structural tools such as monetary policy and fiscal policy with China's economic structure and domestic financial development, together with the correct and effective structural reform, can solve the deep-seated contradictions in China's economy from the root. At present, China's economic system reform is in a critical period of overcoming difficulties, and all sectors of society are looking forward to further speeding up the reform process. Only by further opening to the outside world, building a market economy under the rule of law, seizing market opportunities in time and deepening reform, can we truly solve the deep-seated problems, resolve structural difficulties and promote the inflow of funds into the real economy.

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How the Convergence Happens Between Industries of High-Speed Rail Transportation and Express Delivery?

Hanlin Gao, Meiqing Zhang, and Qilan Zhao

Abstract In recent years, the phenomenon of industrial convergence (IC) has emerged in many fields. By summarizing the previous scholars' studies on IC, this paper deduces the mechanism of action between economic development and IC by constructing a theoretical framework, and extracts three main factors affecting IC: Technology driving, Product innovation and Policy support. Furtherly, this paper takes high-speed-rail express delivery (HED) business as the research object, empirically analyzes the convergence process between high-speed-rail transportation industry (HTI) and express delivery industry (EDI), conducts a quantitative analysis of the relationship between various factors, and demonstrates the long-term stable mutual promotion between two industries. This paper concludes that the rapid development of China's express industry is not only inseparable from the promotion of industrial integration, but also accelerate the process of industrial convergence.

Keywords Policy · Technology · Product · Parcels · Operation mode

1 Introduction

In 2018, the total mileage of high speed rail has reached 29, 000 km and the national delivery volume has been over 50 billion pieces. With the joint venture between China Railway Express and SF Express founded in September, 2018, the development of High-speed-rail express delivery (HED) has been entered a period of rapid development. The services of transiting time-sensitive parcels through high-speed rail (HSR) started in 2012, and using the unexploited capacity of the HSR network to

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transport cargos has been proved to be feasible and necessary in practice. Hundreds of high speed trains have been loaded with parcels and shipped across the country.

Although HSRs are mostly used for transporting passengers [1], investigating the feasibility of coordinating freight and passenger flows using existing and forthcoming rail infrastructure has been a new trend in recent years. Pazour et al. also believes HSR system is attractive alternative to reduce freight congestion for the nation, they present an incapacitated network design model and illustrate how the modelling approach could be used to evaluate the impacts of a HSR network [2]. Liang et al. explore optimal operation method through case studies of China France and Germany, concludes that dedicated high speed freight trains are better than mixed trains at exploiting merits of HSR and achieving economies of scale [3], but Erterm and Özcan insist using the same train for transporting both freight and passengers provides more time saving in the operation system through mathematical models [4]. Bi et al. empirically analyze the adaptability of the express delivery on China's HSR network, on which express parcels among 27 provinces are carried. Results show that the average utilization rate of transportation capacity accounts for approximately 5.5% of the total transportation capacity of the entire HSR network, but the transport volume of parcels will reach the limit of capacity in 2021 [5].

This paper believes that discussing the business only from high-speed-rail transportation industry (HTI) industry perspective as scholars have done cannot reveal the development of HED business completely. However, others analyzes both parties of HTI and express delivery industry (EDI) are more focus on qualitative analysis. For example, Ding et al. built game models to conclude appropriate cooperation mechanism is the key to enlarge express market together [6]. The other quantitative analysis mainly about building AR-GM models to forecast parcels demand to reveal the huge potential market in near future [7]. Instead of paying attention to the volume of express delivery parcels, this paper believes a new type of convergence has emerged and tries to propose a framework to explain how it happens and reveals the cointegration relationship between HTI and EDI.

Industry convergence—the merger of hitherto different industries—is a phenomenon that has had a profound effect on several industries. The first use of term "convergence" is attributed to Rosenberg [8], who stated that changes in the machine tool industry inspired the expression "technological convergence". He employed the term to describe processes of blurring of boundaries between unrelated industry sectors. Current innovation paradigm clearly shows that the notion of "industry" is changing, innovation no longer occurs within single boundaries or industries. High-speed rail transport service, for example, involves more than rail construction, information and communication technologies are combined with the mechanical domain lead to thousands of trains successfully operating every day. It is necessary to find out how industrial convergence happens and what kind of motivation, drivers and processes are behind. Hacklin et al. claim that convergence occur in four stages: (1) knowledge convergence, (2) technological convergence, (3) application convergence, and (4) industrial convergence [9]. Geum et al. identify four types of industry convergence based on 100 successful Korean cases of industrial convergence: technology enhancer, policy-driven environmental enhancer, service-integrated social business generator, and technology-driven new value generator [10].

The booming development of China's express delivery industry benefits from the process of integration with multiple industries. For example, the convergence with e-commerce, information processing, finance and other industries of the tertiary industry has diversified online shopping channels, accelerated transaction speed, improved mutual trust between buyers and sellers, and guaranteed transaction security. As a leader in China's private express industry, SF Express has started to focus on how to improve transportation efficiency in recent years. Different from traditional transportation, HSR, transportation is characterized by fast speed, large capacity, eco-friendly and weather-proof, which marks the birth of a new efficient transportation technology.

Most of literatures refer to the convergence between rail transport focuses on its relationship with tourism industry since HSR are mostly used for passenger travel. Seldom scholars focuses on the HSR freight [5], let alone the convergence between express delivery industry and rail transport industry. but this paper believes that transportation industry convergence is becoming a new driving force for industrial development and economic growth.

As shown in Fig. 1, the rapid and stable economic development has improved the consumption level of residents and stimulated the market vitality. In the context of the rapid development of HSR network, the time-space compression effect has become increasingly prominent. In order to meet people's increasing demand for time-sensitive items, many kinds of innovative technology has been developed and applied rapidly, technology convergence provides a strong support for the new product, with the development of convergence process and emerging service industry, governments found that policy must be adjusted to adapt to the new demand structure. Indeed, the introduction of a series of supporting policies has created a good development environment for industrial integration and pushed it towards maturity. The emergence of new industries will no doubt make an influence on various related industries from many aspects, such as: structure evolution, organization pattern and

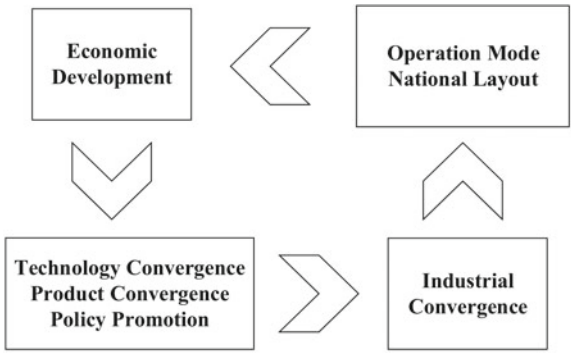

Fig. 1 Framework of convergence's emergence

region distribution. The creative destruction of industry convergence will affect enterprise through restructuring value chain and business model, and then transfer into the catalytic strong impetus of economic integration, make comprehensive influence on the whole economy society.

In the next section, this paper qualitatively and empirically analyzes the emergence process of industrial convergence. Section 3 reveals national distribution of HED service and suggested modes for different regions. The last part ends with some suggestion and conclusion.

2 The Emergence of Industrial Convergence

2.1 Essential Factors Promote Industrial Convergence

High-speed rail transport, as a special type of rail transport, is mostly used for passenger travel in China due to the possibility of shipping cargos was not taken into account at the time of initial design and construction. However, with the rise of e-commerce and development of domestic economy, the increasing demand for inter-city parcels lead to the requirement of express transport. Private enterprises try to rent the high-speed checking train, which is empty and operate every day in the morning to check the safe problem, to solve traffic congestion of goods.

The cooperation on services between companies in different industries is often the beginning of industrial convergence. Hacklin et al. defined the convergence as innovations that emerge at the intersections of clearly defined industry boundaries, producing a much broader impact. This paper believe that the emergence of industrial convergence usually promoted by three generators: technology enhancer, product generator and policy-driven environmental enhancer. This paper believes that it is the maturing of these three factors promotes the emergence of industrial convergence between HTI and EDI.

2.1.1 Technology Driving

One of the important reasons that not transporting cargos through HSR is that its axle load in China is limited under 17t, much lower than the average weight of normal freight train, 21t. What's more, the CRH series high-speed trains (HST) that manufactured before 2017 have little room for passengers' luggage, let alone extra freight.

However, things changed fast in recent years. With the occurrence of new generation CR series of HSTs that has been designed with freight carriage, cargo shipping services are becoming routine between some cities. In 2018, China Railway Rollingstock Corporation (CRRC) claimed that the exclusive high-speed freight trains has been manufactured and will be used in 2019, such highly specialized technology will not only release the limitation of supply capacity, but also promote the process of transport industrial convergence.

During the period of golden week of e-commerce, there were about average daily 700 HSTs transporting parcels, 132 of them reserved a whole carriage, 20 of them are checking trains, which lead to a tenfold transport capacity increase from last year. These examples involve technological advances and improvements in existing products and technologies, at meantime, the development of technology will also be strengthened with the increasingly prominent economic effect.

2.1.2 Product Innovation

With the quick march of life rhythm, people propose higher and higher requirements for timeliness of product and services, especially for the time-sensitive items such as fresh fruit, seafood, and high value-added goods like business letters, medical equipment. The development of online shopping has created billions of express parcels shuttling among cities, traditional transport mode can no longer meet the need of shippers well. In 2012, a series of HSR express delivery services emerged in Guangzhou and spread to all the high-speed stations in 2016, however, these services are offered to meet passenger's urgent requirement, not to participate in the market competition until the joint venture CRSF set up.

From the Table 1, it can be seen that, among all the private express delivery enterprises, Shunfeng Express Co., Ltd. (SF) takes the leading position with its fast, safe and efficient transportation service of time-sensitive goods, which benefits from its strong air freight network. China Railway Express Co., Ltd. (CRE) is the only express company that can exploit HSR resources to operate express delivery due. The deep cooperation between the two companies has prompted the emergence of new express products and services: "Arrived Extremely", which is a kind of "door to

Table 1 Delivery companies ranked by major time-limited indicators

Rank	Full-time	Origin-process time	Transport time	Delivery-time	Last-mile time	Just-in-time rate
SF	1	1	2	1	1	1
EMS	2	2	1	2	8	2
YunDa	3	6	3	5	5	3
ZTO	4	4	4	7	4	4
YTO	5	3	6	6	7	5
BEST	6	8	5	8	3	6
STO	7	5	7	4	9	7
ZJS	8	9	9	3	2	9
TTK	9	10	8	9	6	8
FAST	10	7	10	10	10	10

Table 2 Comparison of pollutants emission among different transportation mode

Annual Emission (kg/cap)		China	USA	OECD
Rail	CO_X	0.031	0.17	0.096
	NO_X	0.53	3.69	1.98
	SO_X	4.02	11.49	6.45
Aviation	CO_X	1.76	9.62	5.43
	NO_X	6.12	42.11	22.6
	SO_X	9.25	26.43	14.86
Truck	CO_X	1.81	9.9	5.58
	NO_X	2.63	18.08	9.72
	SO_X	4.02	11.49	6.47

door" service finished within 10 h and has been operated along the corridor between Beijing and Shanghai. At the end of 2018, the services had covered 58 cities and 413 high-speed rail lines had been used in operation.

2.1.3 Policy Support

Many industrial convergences seek to achieve environmental sustainability, because environment issues have become an increasing concern for both public and government over the last few years. As transportation growth contribute a lot the negative environmental impacts, governments are desperate for a more eco-friendly, cleaner transport tool. Compared with other modes of transport, the pollutant emission of rail is relatively small. Especially, HSR transport has been favored by governments due to its well performance in supporting sustainable development and reducing environmental burdens (Table 2).

Nowadays, a series of support policy documents has been issued by China Railway Companies and governments, includes listing HED as the one of the main services to develop, encouraging the R&D on the flexible organization of EMUs, adding freight vehicular access at high-speed rail station, etc. Under the background of such policy support, the innovation of high-speed railway industry is more frequent compared with other industries. The types of high-speed trains are upgraded every year, the kinds of services has been elaborated and humanized, the degree of cooperation between enterprises is deepening year by year.

2.1.4 Empirical Analysis of Industrial Convergence

Since the cointegration was presented by Engle and Granger in 2001 [11], it was soon afterward adopted to seek the connections of macroscopic variables in economic fields. As for transport area, the methodology was used to explore the relationships between transport volume and economic development. Therefore, in this section, this paper tries to use cointegration theory to empirical analyze the relationship between HSR and express industry.

In order to avoid "spurious regression" phenomenon, a stationary test on the time series should be introduced before regression. The stationary series is marked as $I(0)$, and the non-stationary time series X_t is d-order integrated if its d-order difference is stationary, as shown by $X_t \sim I(d)$.

Usually, the general equation of ADF test is shown:

$$\Delta X_t = \sigma_0 + \gamma X_{t-1} + \sum\nolimits_{i=1}^{p} \rho_j \Delta X_{t-j} + \eta_t \tag{1}$$

where $\eta_t \sim \text{i.i.d.}\left(0, \sigma_\eta^2\right)$, p is the autoregressive lag length large enough to eliminate possible serial correlation in η_t and σ_0 is the coefficient of interest. Conventionally, if $\sigma_0 = 0$, the series contains a unit root implying non-stationary, whereas if $\sigma_0 < 0$, there is no unit root implying stationarity. In the ADF test, the null hypothesis of unit root, i.e. $H_0\colon \sigma_0 = 0$ is tested against the alternative hypothesis of unit root, i.e. $H_1\colon \sigma_0 < 0$ using the t test of individual significance.

In this paper, we use GDP represents the development of economy, the mileage of HSR represents technology, the income and volume of express delivery represents product, dummy variable D_1 represents whether there is support policy, population as the tool variable, so X_t in (1) can be EX_t, POP_t, HSR_t, GDP_t, then the ADF test of this study is shown in these models:

$$\begin{cases} \Delta \mathrm{EX_t} = \sigma_0^{(1)} + \gamma^{(1)} \mathrm{EX_{t-1}} + \sum_{i=1}^{p} \rho_j^{(1)} \Delta \mathrm{EX_{t-j}} + \eta_t^{(1)} \\ \Delta \mathrm{POP_t} = \sigma_0^{(2)} + \gamma^{(2)} \mathrm{POP_{t-1}} + \sum_{i=1}^{p} \rho_j^{(2)} \Delta \mathrm{POP_{t-j}} + \eta_t^{(2)} \\ \Delta \mathrm{HSR_t} = \sigma_0^{(3)} + \gamma^{(3)} \mathrm{HSR_{t-1}} + \sum_{i=1}^{p} \rho_j^{(3)} \Delta \mathrm{HSR_{t-j}} + \eta_t^{(3)} \\ \Delta \mathrm{GDP_t} = \sigma_0^{(4)} + \gamma^{(4)} \mathrm{GDP_{t-1}} + \sum_{i=1}^{p} \rho_j^{(4)} \Delta \mathrm{GDP_{t-j}} + \eta_t^{(4)} \end{cases} \tag{2}$$

Note that the series $\{EX_t\}$, $\{POP_t\}$, $\{HSR_t\}$, $\{GDP_t\}$ are stationary around the level 0.05 after 2-order integrated and specific results are presented in Table 3.

Table 3 Stationary test results of time series

Time series	ADF statistics	5% critical values	Prob	Test results
$\Delta^2\ EX_t^i$	−3.1807	−2.0063	0.0066	EX_t^i ~ I(2)
$\Delta^2\ EX_t^v$	−3.3757	−2.0063	0.0049	EX_t^v ~ I(2)
Δ^2 GDP	−3.9869	−2.0212	0.0025	GDP ~ I(2)
Δ^2 LnGDP	−4.4047	−2.0063	0.0011	LnGDP ~ I(2)
Δ^2 HSR	−4.7817	−2.0063	0.0006	HSR ~ I(2)
Δ^2POP	−3.0000	−2.0062	0.009	POP ~ I(2)

As seen in Table 3, "$\triangle^2$" indicates second difference, "Ln" indicates natural logarithm, "EX_t^i" represents the income of intercity express and "EX_t^v" represents the volume of intercity parcels. 2-order difference of all the variables are stationary. In the model, the population's unit is billion, the GDP's unit is trillion RMB, the HSR's is mage meter, the intercity express volume's is billion pieces, and the intercity income's is billion RMB.

Furtherly, by formulating the cointegration regression, quantitative analysis will be shown about how much influence HSR scale has made on the volume and income of intercity express. The basic models are as follow:

$$EX_t = \alpha_0 + \beta_1 LnGDP_t + \beta_2 HSR_t + \beta_3 POP_t + \mu_{et} \tag{3}$$

$$HSR_t = \theta_0 + \beta_4 LnGDP_t + \beta_5 EX_t + \mu_{ht} \tag{4}$$

$$D_1 \times HSR_t = \theta_1 + \beta_6 LnGDP_t + \beta_7 EX_t + \mu_{dht} \tag{5}$$

$$D_1 = \begin{cases} 1 & \text{Without Policy} \\ 0 & \text{With Policy} \end{cases} \tag{6}$$

As assuming HED only focuses on the trunk transport, the intra-city express is out of service, so we defined "EX_t^i" and "EX_t^v" as explained variable receptively in Model 1, HSR as explained variable in Model 2, and $D_1 \times HSR$ as explained variable in Model 3 (Table 4).

As shown in Model (2) and (3), the relationship between population and HSR scale is not stable. In fact, China has Beijing-Shanghai HSR with 1318 km long, which connects the two megacities with the population both over 20 million, but also has Lan-Xin HSR with 1776 km, which connects two cities both only with 3.5 million people. A low density of population around causes that the revenues from HSR lines cannot even cover the interest on construction loans, what's more, a constant negative

Table 4 Cointegration test results of time series groups

	Model (1)		Model (2)		Model (3)	
	EX_t^i	EX_t^v	HSR		$D_1 \times HSR$	
HSR	0.04***	0.058***	–	–	–	
GDP	0.03***	0.046***	−0.43	−0.36	−2.47**	−2.58**
POP	1.48***	1.173***	−29.9***	9.77	5.84**	−7.77***
EX_t^i	–	–	17.96***	–	–	60.21**
EX_t^v	–	–	–	11.40***	39.88**	–
R^2	0.997	0.996	0.983	0.982	0.824	0.807

*p < 0.1, **p < 0.05, ***p < 0.01

relationship between GDP and HSR scale indicates that the speed of HSR extension is too fast in terms of the GDP growth of China in recent years.

However, it can be clearly seen from the result of Model (1) that the scale of HSR, GDP and population all have a positive impact on express industry. From Model (1), the result indicates that the bigger population and GDP, the greater demand for the intercity parcels. Indeed, 6 of top 10 cities of China with biggest express volume are also in the list of top 10 cities with biggest GDP and population in 2018. What's more, compared with Model (2), the coefficients that indicates influence express industry made on HSR is larger and more significant in Model (3) since the support policy for HED started from 2014, indeed, the influence has been enhanced and more obvious after that.

3 Layout and Operation

3.1 National Layout of HSR Express Delivery Services

Generally, we define HED service as a kind of "Door to Door" delivery service that using HSR to finish the trunk transport. Initially, such service emerged in Europe with the HSR network widely built in the 1990 s. For example, the annual turnover of the joint venture company established by the French postal department and railway department is as high as 5.8 billion yuan at that time. The operation mode of goods transportation by HSR brings huge profits to the railway department, and meanwhile saves social logistic costs.

The HSR transportation industry has obvious economies of scale, which is mainly reflected in two aspects: scale economy of network transportation density (the total mileage has almost covered the cities with the population over 200,000), and scale economy of transportation means (over 3000 units of EMUs). In this paper, we select CRSF as the representative of companies that operating HED, not only because more than 65% of its own business is HED, but also because its services occupies over 80% of the whole HED market.

It can be seen from Fig. 2 that cities with intensive express parcels volume are mainly distributed at the southeast coastal areas, especially forming a distribution trend with Beijing-Tianjin-Hebei region (BTH), Yangtze-river Delta and Pearl-river Delta as the core, which is also consistent with the distribution pattern of China's economic development. The average daily volume of express delivery in all cities is above 40k pieces, and the average daily number of express delivery in seven cities is above 150k pieces, namely Shanghai, Shenzhen, Guangzhou, Beijing, Dongguan, Suzhou and Hangzhou. They are also the node cities of the four vertical and four horizontal high-speed rail network, so this paper believes that these cities will be the hub cities for the development of high-speed rail express in the future nationwide.

As can be seen from Fig. 3, the HED flows are mainly distributed between the four most developed cities in China, and the distance between them are respectively

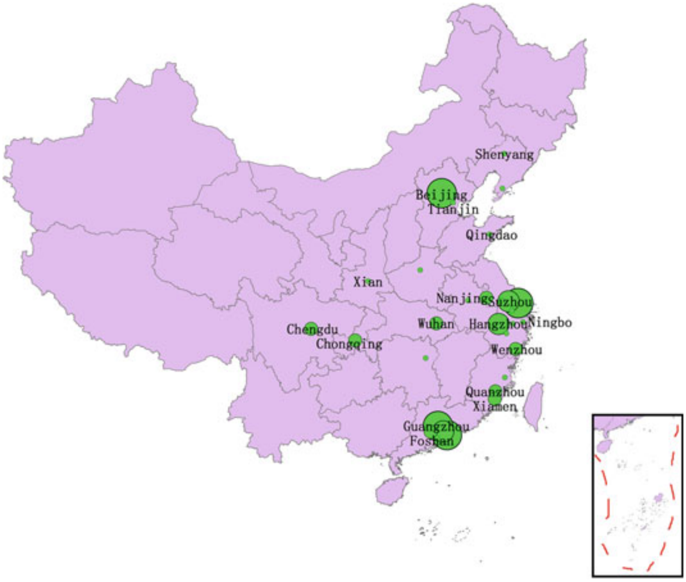

Fig. 2 Distribution of top 30 cities with largest delivery volume

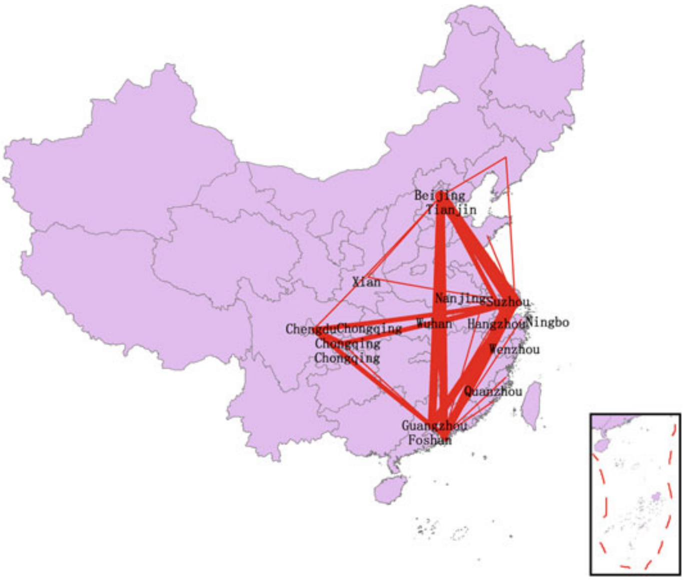

Fig. 3 Distribution of HED flow volumes among cities

1318 km (Beijing-Shanghai), 1623 km (Shenzhen-Shanghai), 2400 km (Shenzhen-Beijing), 1790 km (Shanghai-Guangzhou), and 2300 km (Beijing-Guangzhou). It is generally believed that HSR transportation can give full play to its advantages of large volume and fast speed in the mid-long distance. Therefore, in the foreseeable future, the express volume between these cities will continue to grow and stay in the leading position for a long time. Compared with the eastern region, the development of express delivery within cities in the central-western regions and northeast China is relatively backward, and there are also fewer connections between cities.

3.1.1 Appropriate Operation Mode for Different Regions

In this paper, we divided the operation mode of HED services into three: piggyback mode, using the cabinets or reserved carriage of trains to transport; check-train mode, using the space of the train that operating ever day morning for checking safety problem; freight-train mode, using the exclusive high-speed freight train to finish the transition.

Now, let's take the "Golden Week" of 2018 as an example, which is the period that parcels transport demand soared most of whole year. There were about 700 HSTs transporting parcels every day, though only the former two modes were taken in practice. With the development of a series of new freight EMUs and its application in the future, the capacity will expand rapidly. Therefore, this paper takes all three modes into consideration (Table 5).

From the perspective of single train, piggy-back mode‘s capacity is small, and the train cannot unload at the intermediated station due to it only stop for about 3 min. Although such mode only suits for transport parcels from starting to terminal station, it is still the main mode for HED service because the operating number is so large that almost cover the whole network.

Check-train mode's capacity is considerable, but as it can only operate very few trains within the jurisdiction of 18 railway group company at each day's morning, this mode is applicable to the medium-distance transportation with dense cargo flow, such as the cities located within BTH region, Yangtze-river Delta and Pearl-river Delta (Fig. 4).

The freight-train mode will be put into operation in near future. Due to its large volume and fast speed, it is suitable for mass transportation between the three most

Table 5 Comparison among different operation modes

	Piggy-back mode	Check-train mode	Freight-train mode
Capacity	<5t	<20t	<150t
Existing number	700	20	0
Load distance	200–2000 km	200–1000 km	200–2000 km

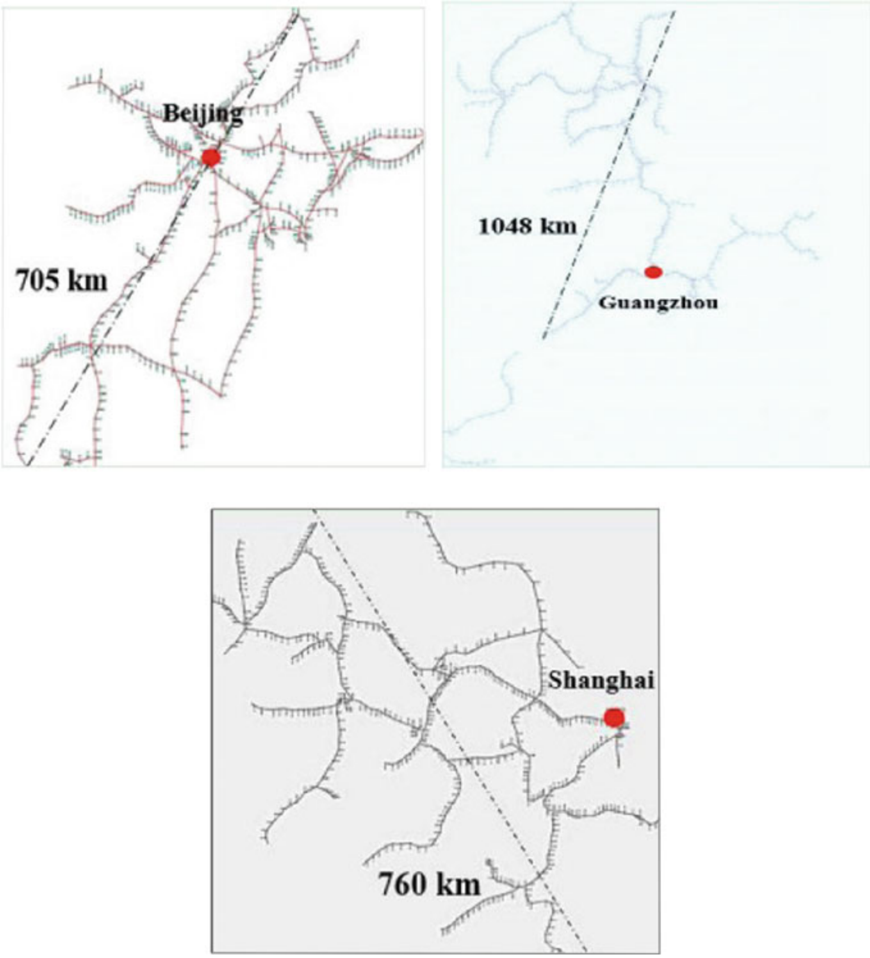

Fig. 4 Jurisdiction of main railway group companies

developed regions, and the transportation route can avoid the relatively congested Beijing-Shanghai and Beijing-Guangzhou high-speed railway. It is believed that this mode can greatly reduce the existing freight cost and activate market demand.

4 Conclusion

Based on the deep cooperation between China Railway Express and SF Express, a series of complementary transport products had been developed. Under the background of increasing demand for time-sensitive goods, the business scale has been rapidly expanded. This paper explores the interactional mechanism between the industrial convergence and economic development through the establishment of cointegration model and case study. Moreover, technology driving, product innovation and policy support are considered as three engines of promoting HED industrial convergence. Furtherly, the evolution of the industrial convergence promotes the development of economy through the evolution of transport organization and the adjustment of the network layout, which leads to a healthy economic development, thus preliminarily concluded that the mechanism of action presents a positive feedback loop effect. As the data length is not long enough, robustness of the results needs further research, but its mutual promotion effect has been clearly presented. In addition, this paper finds that existing HED businesses are mainly concentrated between Beijing, Shanghai, Wuhan, Guangzhou and Shenzhen, after analyzing the operation advantages of different transport modes, this paper offers correspond suggestions for the local policy-maker and enterpriser to make decision.

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Empowering Leadership Fosters Service Employees' Job Crafting

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Abstract Based on conservation of resource (COR) theory, we explore the influence of empowering leadership on service industry employees' job crafting. Multi-level data were collected employees nested within work teams in the service industry. Our findings suggest that empowering leadership is positively associated with job crafting via psychological availability. Moreover, perceived organization support significantly moderated the positive relationship between empowering leadership and job crafting. The present study reveals the cross-level effects of empowering leadership and provides practical suggestions to foster employees' job crafting in organizations.

Keywords Empowering leadership · Job crafting · Psychological availability · Perceived organization support

1 Introduction

Traditional job designs focus on "top-down" style, which mainly conducted by managers. However, with new generations of workers are flooding into the workplace, scholars have pointed out that "top-down" job designs neglect the autonomy of employees and cause limitations. In fact, subordinates are not just required to implement assignment prescribed by the organization but are also expected to initiative to participate in the job design [1]. Job crafting represents the changes that

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subordinates perform in the assignment or interpersonal boundaries of their work with their capabilities, needs, and preferences [2]. In other words, job crafting can be regarded as a self-initiated and extra-role behavior, which is positively related to various positive outcomes. Some researchers have investigated the antecedents of job crafting, include big-five personality, job autonomy, career orientation, etc. But, most of them are theoretical speculations, and the empirical evidence about the antecedents of job crafting from the organizational level is relatively modest [3]. Furthermore, most previous studies of job crafting carried out in non-service industry situation. Therefore, studying the antecedents of job crafting from the organizational level is supposed to make some contribution.

Empowering leadership refers to the leadership style that supervisor appreciate their subordinates' capacity, stresses the importance of the work of the employees, engage subordinates in strategy formulation, and eliminate workplace barriers for employees [4]. According to Ilgen and Hollenbeck, individuals who in possession of work autonomy are more likely to make redesign of job [5]. Slemp et al. also found that employees with greater free space are more likely to perform extra-role behavior [6]. So, exploring the relationship between empowering leadership and job crafting is extremely important and meaningful.

Early studies suggest that empowering leadership promotes extra-role behavior mainly by stimulating employees' intrinsic motivation. However, motivation is a necessary and insufficient condition. Employees' perception of available resources is equally important. Psychological accessibility refers to subordinates' available awareness of the physical, affective and cognitive resources in the work, which has an important impact on individual attitudes and behaviors [7]. So as to enhance employees' awareness of the availability of their own resources, thereby improving their psychological availability. Thus, by drawing on conservation resource theory, we further explore the function of psychological availability in the impact process of empowering leadership on job crafting.

Job crafting is not fostered by a single factor, but by both personal and environmental interaction effect. Job crafting is not only the result of individual efforts but also the strong support of the organization. Perceived organizational support (POS) is the human's psychological feeling of the degree of organizational support. Therefore, the current study assumed that exist a remarkable difference in the influence of empowering leadership on employees' job crafting under diverse conditions of perceived organizational support.

2 Theory and Hypotheses

2.1 Empowering Leadership and Job Crafting

To meet the needs of work teams and horizontal organizations, managers have replaced traditional supervisory leadership with empowered behaviors. Zhang and

Bartol conceptualized empowering leadership as the style of influencing others that release of authority and delegating with subordinates, providing subordinates with autonomy, motivating support subordinates' learning and giving work guidance [8]. Considerable evidence indicates that empowering leadership can fuel employees to perform productively beyond the limits, such as increasing organizational commitment, enhancing creativity and improving work performance.

Job crafting is considered an initiative behavior that individuals actively use resources of the work to construct their job boundary to maintain work meaning [2]. Job crafting is comprised of questing work resources as well as challenges, and lessen work demands. Researchers have clearly demonstrated that employees' job crafting can be facilitated by their peers, like coworkers or superior [9]. As a representative of the organization, leaders constitute an essential factor impacting on employees' work outcomes. Working with an empowering leader, employees may actively participate to craft their jobs.

First of all, compared to other leadership styles, empowering leader exhibits more delegation behaviors, it facilitates employees to give full play to their own intelligence and wisdom in the workplace. Employees are granted more autonomy without direct supervision or intervention. It helps establish a free work context, where they strive to explore diverse approaches and seek resources to improve job performance. Second, empowering leader show confidence to their subordinates in identifying difficult works and encourage employees to be more involved in tackling these problems. Such empowering leadership behaviors are more likely facilitating rather than directing and controlling employees, employees possibly favor in seeks the challenge. Under empowering leadership, employees develop skills and better adapt to their work environment. Third, empowering leadership provides information and resources to help employees complete tasks like a coach. Thus, employees become capable and engage in reducing demands behavior. With the help of empowering leadership, employees actively working to bring about a change to meet the expectations of the leader.

Based on these aforementioned arguments, we propose:

Hypothesis 1: Empowering leadership is positively related to employees' job crafting.

2.2 The Mediating Effect of Psychological Availability

Psychological accessibility is a psychological state that helps people decide whether and how to engage in organizational activities. According to May et al., possession of available resources can influence employees' psychological availability [9]. We speculated that psychological availability shaped by empowering leadership motivate employee job crafting.

As empowering leaders communicate positive vision through grant of power or delegation of authority, attach the importance of their employees' work, and allow employees to participate in decision-making. This could greatly make employees feel trusted and supported by organization. It was found that individual participation promotes high levels of psychological availability. Additionally, employees achieve more real autonomy from empowering leaders, which enforce employees' ability to control the working environment. Furthermore, empowering leadership provide opportunities for skill development and express concern for work condition. Employee perceived care has been found to be an important facilitator to psychological availability [10].

On the one hand, crafting is a process of trial and error, full of uncertainty and risk. Employees may avoid potential punishment for spontaneous job crafting. With high psychological availability, employees believe that they can take advantage of job crafting and reduce uncertainty, so that they pay more attention to how to solve problems and thus harvests the best work and the career result [11]. On the other hand, employees with psychological availability have more job participation and job engagement. In the face of change, whether they are independent or cooperating with others, they are willing to participate in job modifying process, initiative to make every effort to meet the expectations of leaders.

According to the conservation of resource theory, individuals always have the ability to acquire and maintain their own resources. Individuals with more resources have better resource returns and more likely to facilitate proactive behavior [7]. Empowering leadership provides subordinates with conditional resources such as power and decision-making, and enhance perception of resource availability during crafting process, that is, improve employees' psychological availability. Individuals with more resources have better resource returns, so employees with higher psychological availability tend to invest more resources, thus make a positive change (i.e., job crafting).

Hypothesis 2: Employees' psychological availability mediates the relationships between empowering leadership and job crafting.

2.3 The Moderating Effect of Perceived Organizational Support

According to the conservation of resource theory, resources can be divided into four categories: physical resources, conditions, personal characteristics, and energy. Organizational support can also be classified as an energy resource. POS is considered employee perception about the extent to which organizations pay attention to their contributions and their well-being [12]. A high perception of POS suggests that employees feel that organization values. Employees with high POS feel good organizational environment and mutual help colleagues, reduce environmental uncertainty and increase the possibility of employees using available resources for modification. However, individuals with lower POS should not have sufficient confidence and strong will to make change. Though employees with high psychological availability can perceive more available physical, emotional, and psychological resources for change, their additional efforts are not recognized and supported by the organization.

Hypothesis 3: POS will moderate the positive effect of psychological availability on job crafting.

3 Method

3.1 Procedure and Sample

We collected data from supervisors and their direct reports from 57 full-service hotel in first-tier cities of China. Questionnaires were collected in groups. Each group has one leader (manager) and 5 to 7 of his/her subordinates. The survey for subordinates asked them to report the supervisor's empowering leadership, psychological availability and POS among group members. Before the test, we assigned an identification number (group number and individual number) of questionnaire to ensure the precise matching of group and individuals. All samples were guaranteed by confidentiality of their answers. In total, 65 leadership and 320 subordinate dates were distributed. Delete the incomplete questionnaire, 49 leadership questionnaires and 293 subordinate useable dates were returned, generating a response rate of 91.56% for subordinates and 75.38% for superiors. Among the participating, subordinates 69.31% were women with mean age of 34.07 (SD = 4.78), the mean organizational tenure was 13.26 (SD = 11.15), 72% received high school degree or below. Of the participating leaders, 9% were female with mean age of 35 (SD = 5.78), the mean group tenure was 3.86 years (SD = 1.99), 45% received university education.

3.2 Measures

The present study surveyed empowering leadership with a 12-item scale (see Ahearne, M., Mathieu, J., and Rapp, A.). Sample item included "My leader patiently instructs my work frequently" and "My leader often encourage myself to make work-related decisions on my own". The Cronbach alpha was 0.770. Psychological availability was evaluated with five items from the delegation questions developed by May et al.. Sample items included "I believe I have the ability to show the appropriate emotions at work" and "I believe I can handle the physical needs of my job". Cronbach's alpha was 0.748. We measured POS with 8 items adapted from Eisenberger et al., which was used within the hospitality literature. Cronbach's alpha was 0.760. Sample items included "Organization cares about my career development" and "Organizations often give me help and support when I need it". job crafting's scale has 21-items came from Tims et al. study. Sample items included "I try to improve my skill" and "I can arrange my work in a reasonable and orderly way to reduce my stress". Cronbach's alpha was 0.932. We controlled the major demographic variables in our study. In order to ensure the reliability and validity of each scale, the principle of two-way anonymity and scientific translation procedure are adhered to in the formation of the scale. Scales were scored using a 5 point Likert type scales. The scope intense from 1 does not agree expression to 5 intense agreements expression.

3.3 Analysis

Because the present study had a dual-level hierarchical structure model, so we used hierarchical linear modeling (HLM) to process data. HLM is a forceful method that can test cross-level models and concurrently divide the variance of variables into the components of within and between group.

Data analysis was performed in three steps. First of all, confirmatory factor analyses (CFA) was conducted to test distinctiveness of factors. Secondly, to assess the potential between-group variance of variables, two forms of intra-class correlational coefficients (ICC) were conducted, which is a prerequisite for multi-level analysis. Furthermore, HLM was performed to examine whether empowering leadership of group-levels might explain variance in subordinate-level outcomes. Finally, OLS regression analysis was performed to test the moderated role of POS.

4 Results

4.1 Confirmatory Factor Analyses (CFA)

We conduct CFA through maximum likelihood estimation. The hypothesized four-factor model (empowering leadership, psychological availability, POS, job crafting) had a good model fit ($Chi\text{-}Square = 728.71$, $df = 300$, $p < 0.01$, $[CFI] = 0.960$, $[TLI] = 0.927$, $[RMSEA] = 0.068$, $[SRMR] = 0.035$). We also compared the hypothesized four-factor model (empowering leadership, psychological availability, POS, job crafting) with several alternative models. Results indicated that four-factor model revealed a dramatically better fit than any other optional models.

4.2 Descriptive Statistics and Correlations

The descriptive statistics and intercorrelations of the study variable were showed in Table 1. As we can see, all variables are related to each other, providing initial support for the hypotheses.

Table 1 Descriptive statistics and intercorrelations

Variables	Mean	SD	1	2	3	4	5	6	7	8
1. Gender	1.213	0.491	1							
2. Age	2.892	5.787	0.011							
3. Education	2.558	0.783	−0.022	0.040	1					
4. Job tenure	3.164	11.151	0.045	0.020	−0.062	1				
5. Empowering leadership	4.627	0.666	0.134	0.150	0.017	0.092	1			
6. Psychological availability	3.573	0.712	0.171	0.022	0.010	0.431	0.499**	1		
7. POS	3.731	0.821	0.56	-0.091	0.050	0.128	0.173**	0.181**	1	
8. Job crafting	3.986	0.448	0.26**	0.149	0.129	0.011	0.54**	0.341**	0.451**	1

Note N = 293. Alphareliabilities are in parentheses on the diagonal, *p < 0.05. **p < 0.01

4.3 Aggregation Test

To analyze the suitability of the data aggregation, we conducted ANOVA tests and two interclass correlation coefficients (*ICC[1]* and *ICC[1]*) on empowering leadership by calculating *rwg(j)* values. *ICC[1]* represents a form of proportional consistency, as a criterion for aggregating; *ICC[2]* refers to an prediction of the fitness of the group means criterion for aggregating. *ICC[1]* and *ICC[1]* calculated as follows.

$$ICC[1] = \frac{MSB - MSW}{MSB + [(k-1) * MSW} \tag{1}$$

$$ICC[2] = \frac{MSB - MSW}{MSB} \tag{2}$$

Among them, *MSB* experts between-group mean square. *MSW* experts within-group mean square; *k* experts group size (average).

Results revealed that there was a significant difference between between-store variance and within-store variance for the empowering leadership ($F = 2.01$, $p. < 0.01$). The mean rwg(j) across stores was 0.93 of empowering leadership, representing an acceptable degree of inter-rater agreement. The values of the inter-rater reliability index ICC [1] is 0.329 and the reliability of group-mean index ICC [2] is 0.883. All of these values were comparable to Bliese's (2000) suggestion on team-level constructs. On the basis of these results, we concluded that aggregation was justified.

4.4 Hypotheses Testing

HLM was conducted to examine the hypotheses, effects of the Level 2 predictor. Specific analysis steps are shown below:

First step:

$$L1\colon Y_{ij} = \beta_{0j} + \gamma_{ij} \tag{3}$$

$$L2\colon \beta_{0j} = \gamma_{00} + \gamma_{01} X_j + \mu_{0j} \tag{4}$$

Second step:

$$L1\colon M_{ij} = \beta_{0j} + \gamma_{ij} \tag{5}$$

$$L2\colon \beta_{0j} = \gamma_{00} + \gamma_{01} X_j + \mu_{0j} \tag{6}$$

Third step:

$$L1\colon Y_{ij} = \beta_{0j} + \beta_{1j}\left(M_{ij} - M_{.j}\right) + \gamma_{ij} \tag{7}$$

$$L2\colon \beta_{0j} = \gamma_{00} + \gamma_{01}X_j + \gamma_{02}\mathrm{M}_{.j} + \mu_{0j} \tag{8}$$

$$\beta_{1j} = \gamma_{10} \tag{9}$$

Note: *Yij* represents the dependent variable, *Xj* represents independent variable, *Mij* represents mediate variable, it represents the *i* sample of the *j* group, *M.j* represents the mean of the *Mij* of the *j* group.

Table 2 presents the results of these models. Regarding Hypothesis 1, as we can see, empowering leadership is certainly associated to subordinates' job crafting ($\gamma = 0.671$, $p < 0.01$). Therefore, Hypothesis 1 was verified.

For Hypothesis 2, the test of mediating effects of psychological availability was followed by the procedures of Baron and Kenny's (1986). The first step was to examine the direct effect of independent variable on dependent variable (Hypothesis 1). In Step 2, determine whether independent variable was significantly related to mediateing variable (psychological availability). This requirement was also

Table 2 Hypotheses testing of H1, H2 and H3

Variable	Psychological availability				Job crafting			
Model	M1	M2	M3	M4	M6	M7	M8	M9
Interpret	4.484**	4.577**	4.770**	4.240**	4.350**	4.420**	4.280**	4.450**
Level-1								
Gender		0.020			0.040	0.060	0.06	0.04
Age		0.190			0.080	0.03	0.05	0.03
Education		0.050			0.010	0.00	0.01	0.00
Job tenure		0.080			0.020	0.01	0.02	0.02
PA							0.260**	0.217**
Level-2								
Team scale		0.030	0.010		0.030	0.040	0.030	0.040
Empowering leadership			0.470**			0.671**		0.55**
Variance (τ) Between-group	0.343	0.324	0.242	0.392	0.392	0.225	0.277	0.184
Variance (σ2) Within-group	0.746	0.748	0.747	0.94	0.411	0.374	0.318	0.216

Note for level-1, n = 293, for level-2, n = 49; *p < 0.05; **p < 0.01

supported ($\gamma = 0.470$, $p < 0.01$). Finally, we identified whether the effect (regression coefficient) between independent variable and dependent variable in Step 1 decreased in order of growth (partial mediation) or eliminated (complete mediation) when psychological availability was added in the model. Results showed that empowering leadership has a positive effect on sunbordinates' job crafting ($\gamma = 0.260$, $p < 0.01$), and the positive relationship of the two was reduced but remained significant ($\gamma = 0.210$, $p < 0.01$). Thus, Hypothesis 2 was verified.

Hypothesis 3 stands for an interaction effect on level 1. As Fig. 1. and Table 3 showed, the interaction effect of psychological availability and POS was significant for job crafting ($\beta = 0.192$, $p < 0.05$), indicating that POS moderated the effect

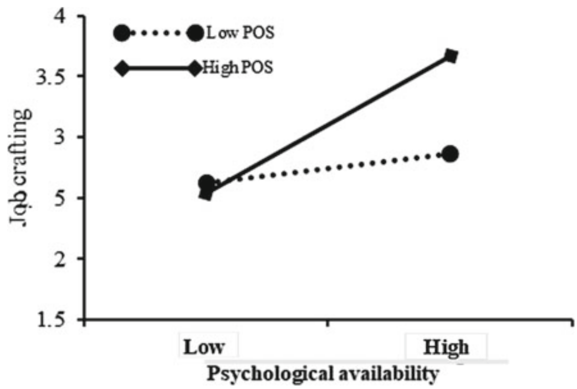

Fig. 1 Moderating effect of leader delegation on the relationship between career uncertainty and psychological safety

Table 3 Index extraction

	β	t	R	$\triangle R^2$
Step 1			0.009	−0.002
Gender				
Age	−0.028	−0.292		
Education	0.028	0.277		
Job tenure	0.093	1.572		
Step 2			0.357	0.346
PA	0.345***	6.699		
POS	0.183**	2.788		
Step3			0.365	0.351
PA × POS	0.192*	1.989		

Note PA = Psychological availability, POS = Perceived organizational support, *p < 0.05, **p < 0.01, ***p < 0.001

pathway between psychological availability and employees' job crafting. Hypothesis was strongly supported.

We also plotted the significant dual-interaction effect with plotting means at ±1 SD. in Fig. 1. As shown in Fig. 1, when employees perceived high levels of POS, the direct effect between psychological availability and job crafting was stronger. On the contrary, it was found that the positive relationship weakened when POS is low.

5 Conclusion and Discussion

5.1 Theoretical Implications

Our study has made possiblelys several theoretical implications to relevant literature. First, we examined the positive effect of empowering leadership on employees' job crafting. Most of the existing researches focus on the individual contributing factors of job crafting, organizational level factor with empirical are limited [13]. The present study proposed and verified that empowering leadership have a large use in facilitating job crafting on the cross-level. Moreover, we extended empowering leadership to service industry. To our knowledge, this the first study empowering leadership in service context. Second, the present study explored the mechanism between empowering leadership and service industry staff job crafting. Drawing on conservation of resource theory, we also found that psychological availability mediated the effect of the relationship mentioned above. It responds to the call for investigating the influence mechanism of organizational situational factors and job crafting [14]. The study uncovered the "black box" between empowering leadership and job crafting, which further enriches the empowering leadership and job crafting by applying conservation resource theory perspective. Third, we demonstrated that the moderating effect of POS. Scholars have found that POS is the key organizational factor that influences employees' crafting behavior. Consistent with their conclusions, we further extended job crafting literature by showing the different effect of POS. Specifically, POS strengthened the positive effect of psychological availability on job crafting. We respond to the call that the relevance of the resource to the specific situation should be taken into consideration when individuals determine the value of resources.

5.2 Practical Implications

Our study may provides some implications for organizational management practice. First of all, leaders should consider empowering leadership to facilitates employees to take the initiative to job modification. Leaders need to make it clear that leadership style play a key role in employees' behavior from enhancing subordinates' job autonomy, decision-making and self-development support. Furthermore, interventions aimed at improving psychological accessibility can also facilitate employees' resources to craft their jobs. To enhance staff perceived availability, managers should establish a harmonious employment relationship and strengthen the construction of the organization team, so that employees can feel the care from the leadership and the support from the team. Our findings contributing to POS revealing that interpersonal differences in perceived support intensity form organization can also impact employees' motivation to display proactive behavior. By means of strengthening organizational justice, improving welfare level and giving employees fair opportunities for promotion, the organization should effectively improve employees' sense of organizational support, make subordinates full of confidence and dare to challenge, so as to promote the occurrence of crafting behavior.

5.3 Limitations, Future Directions and Conclusions

Although our study makes important contributions to theory and practice concerning job crafting, it has several potential limitations. First, cross-sectional design was used for testing hypotheses, failed to analyze the dynamic process of empowering leadership influence on subordinates' job crafting. Future research using a longitudinal design with a time lag may provide more conclusive results concerning job crafting. Second, the present study limits themselves to only psychological accessibility as a mediating variable. Future research can comprehensively consider psychological safety and psychological contract might also mediate relationships between the main effect. Third, we obtained employee job crafting data from their supervisors. Future studies can combine objective data and subjective measures to further validate the research results.

In conclusion, the present study contributes to the research on the relationship of empowering leadership and subordinates' job crafting by using cross-level model that based on service industry situation. Empowering leadership at the group level has a significant positive cross-layer effect on individuals' job crafting via psychological availability. In addition, POS can moderate the relationship between psychological availability and job crafting, and the positive impact of psychological availability on job remodeling will be stronger when subordinates have high level of POS. All in all, the empirical analysis results of the current study provide solid support for all hypothesized relationships. Indeed, there is a lot of uncertainty situation about the work of service industry employees, which provides opportunities for job remodeling. We hope that our study results can provide some reference and enlightenment for the management of service employees.

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Comparative Study on the Regulation Modes of Chinese and American Pharmaceutical Industries

Lu Yu

Abstract This paper studies the policy regulation of the pharmaceutical industry in China and the United States. The main points of this paper is analyzing the formative factors of these regulation modes. There is multiple similarity when the two countries were founded. Then, as time goes on and they have embarked on different paths of development and established completely different regulation model. This paper illuminates the formation reasons about these regulation modes by analyzing the historical and social background of two countries.

Keywords Regulation · Modem · Industrial security · Social background

1 Introduction

In the conference papers of previous years, the author has compared the regulation modes of the pharmaceutical industries in China and the United States through analyzing the relevant laws of the two countries for the pharmaceutical industry. From a macro perspective, the regulation modes of the pharmaceutical industries in the two countries are completely different. This situation comes from the fact that there are few similarities between the two countries in terms of political systems, economic models, industry scale and contents of relevant laws and policies.

However, if we compare the historical background and social conditions of China and the United States during the periods of their founding, we will find that the pharmaceutical industries in the two countries were quite similar at the beginning of their development, and they have formed the current regulation modes in the historical development context. By comparing the historical background of the two's development, this paper combines the current safety conditions of the two countries' pharmaceutical industries to analyze the historical background and realistic significance of such difference.

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2 Literature Review

From a macro perspective, the regulation modes of the pharmaceutical industries in China and the United States are shown in the following Figs. 1 and 2.

As shown in the figures above, the regulation modes of the two countries are completely opposite. China adopts unified legal norms and hierarchical management from top to bottom; while the United States adopts the game-type regulation mode in which the political forces of all parties' target at industry development.

In previous articles, the author has analyzed the regulation mode of the two countries. And the author analyzes the effect of the regulation mode in the two countries. In effect, both regulation modes of two countries have achieved their goals and protected the pharmaceutical industrial security. In the United States, the consultation process among pharmaceutical enterprises, government and industry associations is a process of multi-party game. The main objective of the game is the benefit balance. Since American is leading the world in the medical technology. Its industrial regulation only needs to protect the development vitality of pharmaceutical enterprises and the technical advantages of practitioners. In China, the main approach is government regulation. The reason for using this method is the bargaining cost savings. Since Chinese medical technology is not advanced. The international competitiveness of

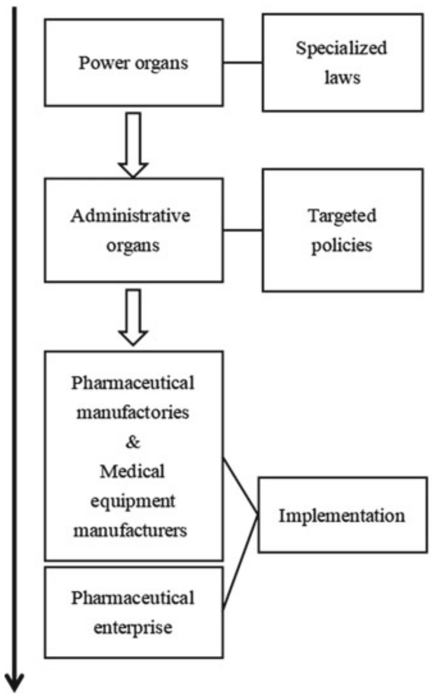

Fig. 1 China's mode: top-down linear mode

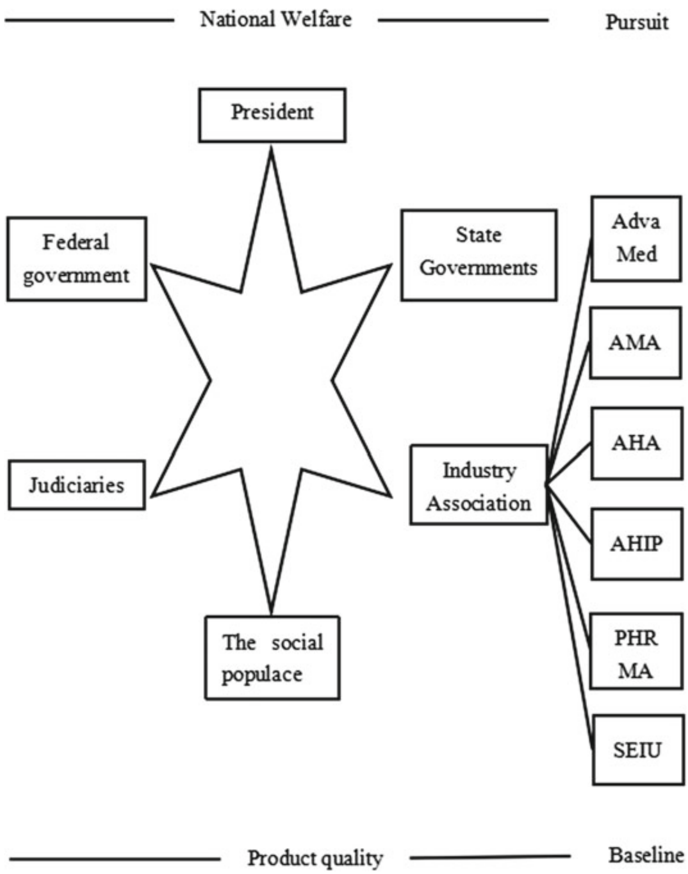

Fig. 2 American mode: an equilibrium mode of multi-party game

this industry is weak. Therefore, the pharmaceutical industry needs to make overall planning and long-term decisions. This has produced the current industrial model.

But there are few research achievements about industrial regulation model in two countries. in the related field, American scholars are more inclined to study medical economics. The main concerns are the quality of services and the behavior of pharmaceutical enterprises. And Chinese scholars are more inclined to study law and policy. The main concerns are the legal interpretation and system reform.

3 Analysis

The reason for the above-mentioned difference lies in the fact that, since the founding of the two countries, they have chosen significantly different development paths, guiding ideology and value pursuit. However, it is worth noting that there were several similarities in social background of China and the United States during their founding. The similarities are as follows:

Backward technological environment: before the War of Independence, the United States mainly served as a source of raw materials for developed countries in Europe. As for its economic production, it mainly produced industrial raw materials and agricultural products. In the field of talents, there were mostly low-level laborers such as adventurous gold diggers, religious losers and those reclaiming wastelands. High-level talents in the field of science and technology did not favor it. During the founding of new China, the long-term war had almost depleted the domestic industry. The high-level technological talents did not gradually return from foreign countries until several years after China's founding, so it was difficult for them to immediately devote themselves to construction in various industries in a short period of time.

International relations dilemma: after the War of Independence, the original interests of the colonial countries could not be guaranteed in the short term. Moreover, the Second War of Independence happened soon after the founding of the United States, so both the United Kingdom which was most powerful in the world at that time and the former colonial countries in Western Europe rejected the development of the United States. Also, after the founding of the United States, Washington, who was the first president of the country, determined the "isolated foreign policy". Due to the background of the Cold War, it was even more difficult for China to be accepted by developed countries in the world at the time of its founding.

Backward infrastructure: generally speaking, from the economic point of view, China and the United States were both agricultural countries at the time of their founding. Their overall development modes were based on extensive development and they did not have a complete industrial system.

To sum up, there were a lot of similarities between China and the United States in terms of their social problems and international environment at the time of their founding. They both adopted the extensive development mode, lacked talents and technologies and had poor industrial foundation and development prospects which were difficult to be expected. However, two non-economic reasons created huge development space for the United States, causing the most fundamental difference in the development of China and the United States:

Based on the value orientation for the founding of the United States and Adam Smith's free economic theory, the United States was urged to pursue free value in a method which was almost like faith and build its own political and economic system mode by taking it as a philosophical basis. Ultimately, it formed a nearly completely liberalized economic market and loose economic policies, which attracted European investment in a large amount for a long time after its founding. Although the United States did not intervene in the European disputes in the political and military aspects [1], it had huge appeal to European capital in the business aspect, particularly in terms of its domestic production under slavery.

In the context of long-term colonial history, at least long-term for the American history at that time, the United States and the United Kingdom and even the entire developed regions of Western Europe did not have significant "civilization or cultural conflict" [2], so the capitalists in the Western European countries were more inclined to invest capital in the United States. It can be imagined that, in the period of the first and second generations after the founding of the United States, the social ideas in Western Europe still regarded the United States as an affiliate of Britain and other colonial countries although the United States was already independent, so the United States was still the best choice for Western European powers headed by Britain at that time to settle down and invest. Therefore, although the United Kingdom used some means to impose economic sanctions on the United States after American Wars of Independence (including the first and second independence wars), these policies were quickly canceled and the United Kingdom recognized the status of ally of the United States [3]. Of course, from another perspective, investors did not do it for the development of the United States, but for their own economic benefits, so such situation directly resulted in increasingly expanded "speculative investment". However, there was very little "development-oriented long-term investment" (There was even American railway investment, which was a well-known economic bubble in history.) As a result, the early US economy still adopted the main economic modes of "specialty export" and "transportation" [4]. Later, the First World War stimulated the independent development of American science and technology and the Second World War enabled the United States to complete its original accumulation and begin to become the most powerful country in the world.

It can be seen from the above analysis that there are many similarities between the United States and China, especially New China at the beginning of its founding. The solutions are nothing more than the following:

To attract talents and technology from the advanced countries in the international league—In fact, China's earliest technological study was originally from the Soviet Union, which was its international "ally".

To give play to its own characteristics and use various means to complete primitive accumulation—China's various economic reforms starting from its founding can be seen as such work and it has made remarkable results by finally establishing a complete nation-wide industrial system.

To seek international allies through value recognition to achieve mutual benefit and assistance—this was the only point which was a huge difficulty for China. Japan and South Korea, which belonged to the same Chinese cultural community, were not China's allies at that time.

More importantly, various indicators were relatively weak in the aspects of talent introduction through the Second World War and development through its own scientific and technological concept, or it was so at least in the initial stage of founding. In other words, the connection between the United States and Europe never stopped even when the industry safety index was extremely low. More importantly, to a certain extent, European developed countries headed by the United Kingdom were in fact the backup bases for the United States in terms of talents, technologies and funds. As an immigrant country with no history, the United States was able to do its utmost to absorb all kinds of high-quality resources and constantly develop its own potential; let alone its local rich natural resources.

However, the situation in China was not ideal. It could not compare to the United States during its founding in terms of political ideas and resource reserves. Interestingly, from the perspective of historical heritage, the national pride and self-confidence of the United States came from victory of the Second World War and even the Cold War, but it neither had much "ambition" nor demanded "American leadership in the world" in the mode of national propaganda at the beginning of its founding. Due to its federal political system and legal mode, the central government of the United States did not have too many political resources to make planning for the industries of the entire country. In other words, it was not able to pay huge administrative cost to meet the requirement of adjustment of national industries. Therefore, in both the objective and subjective aspects, the United States at that time should and could select a path for slow development.

However, it was on the contrary in China. No matter it was because of the communist ideal in the period of founding of the country or the national identity inherited from ancient civilization, both China's central government and ordinary people did not accept that China was an "emerging and promising country without the need to formulate big goal planning". Since the beginning of the founding of new China, it already had the direct goal of "establishing a great new China" and "uniting people of the world". At the same time, from the perspective of historical inheritance or path dependence, its administrative system of being uniformly accountable to the central government and the unity-based national system led to the fact that China could bear huge administrative cost to carry out industrial planning at the state level. Therefore, new China inevitably chose an industrial development path which was completely different from that of the United States.

On this development path, the role of law is totally different, which has caused a number of differences in the choices made by China and the United States. To be specific, the differences include:

Because the United States had different overall national construction goals and thus had different planning for its own industry development, it could bring in capital in accordance with its own characteristics to develop its own industries. However, China had to complete economic construction to improve national confidence and cohesion. This difference can be seen from the preambles of the constitutions of China and the United States. There was only one sentence in the preamble of the Constitution of the United States and the part expressing the basic work of the country was "in order to form a more perfect Union, establish justice, insure domestic tranquility, provide for the common defense, promote the general welfare… (The full text for the preamble of the Constitution of the United States is "We the people of the United States, in order to form a more perfect Union, establish justice, insure domestic tranquility, provide for the common defense, promote the general welfare, and secure the blessings of liberty to ourselves and our posterity, do ordain and establish this Constitution for the United States of America."). By contrast, the preamble of the Constitution of the People's Republic of China consisted of 14 paragraphs covering many aspects such as "historical trace, revolutionary course, party leadership, core ideas, cross-strait relations, ethnic relations and national systems", which showed evidently far-reaching goals.

In terms of domestic situation, at that time, the states of the United States were still separated, the federal regime was not stable and the federal legal rights were not guaranteed. The militia system laid a huge hidden danger for the social stability of the United States at that time. Therefore, except for the development path of liberalizing free market economy, the United States was not able to pay the high administrative costs even if it wanted to plan its own domestic economic development on the whole in a uniform mode. By contrast, China's army and navy forces were quite excellent after the founding and its systems of People's Congress and democratic centralism were highly uniform, so all types of domestic remnants could not pose a threat to the country on the whole. Therefore, China could select the planned economic system with unified planning.

From the perspective of the development pattern of the pharmaceutical industry, a contingent factor determined the difference between the layout of the pharmaceutical industries in China and the United States. It was the international military factor. After the victory of the Second War of Independence [4], the international military environment for the United States was safe at least at that time. It supported the internal development of the United States and more importantly led to the fact that its leadership did not have to pay too much attention to the development of the pharmaceutical industry, because medicine provided by Europe could meet the demand of the United States and all countries did not pay much attention to the pharmaceutical industry at that time. Until the First World War, the United States did not need to focus on developing its own pharmaceutical industry. However, the First World War provided an illustration for the world's research on industrial economic safety, that is, pharmaceutical production and industrial development plays a significantly role in a country's livelihood and economy and even determines the survival of a country [5]; (Before the First World War, Germany occupied the world's top technologies in the pharmaceutical industry, which significantly helped improve their military strength. Also, in the early 20th century, the global flu caused great harm to the United States.) in any case, if the United States could not guarantee its own pharmaceutical supply, its overall national security could not be guaranteed; in particular, it was very difficult for the United States to get the latest pharmaceutical technology after it engaged in war with Germany, causing great impact on its national policy of valuing "latest technologies". Meanwhile, also due to the military factor, inevitability surpassed contingency for China. After its founding, China's layout of the pharmaceutical industry was mainly to ensure military needs and was designed based on two basic requirements of "all people being soldiers" and "preventing foreign enemies" due to historical reasons, the psychology of victims precipitated in the minds of the public and nationwide tide of militarization in addition to the above-mentioned "national ideals". As a result, as is described in Sect. 3 of the report, most of the provinces and key areas of China has established their own manufacturers to ensure essential medicine supply. In other words, the initial development layout of China's pharmaceutical industry was not for the purpose of economy, but for politics and military.

From the perspective of skopos theory, it is called the United States and China's pharmaceutical industry development mode is relatively stable because the medicine industry development trend of two countries has met the development of the industry planning. For the United States, it is already achieved the highest achievement in the world about the pharmaceutical industry in the business category. And for China, it can keep pharmaceutical industry develops itself at home.

For United States, National Health Expenditure (NHE) is the highest of the world. It is expected to exceed $4.3 trillion by 2018, accounting for one-fifth of GDP [6]. The health care system receives 35 million inpatients, 64 million surgeries, 900 million visits to medical clinics and 3.5 billion prescriptions every year [7]. The National Institute of Health is the largest biomedical research institute of the world. There are 6,000 scientists and an annual budget of $30.5 billion [8]. And the most obvious example is there are four American pharmaceutical companies have entered the world rankings. They are Johnson & Johnson (U.S.), Pfizer Inc. (U.S.), Merck & Co., Inc. (U.S.) and Gilead Sciences, Inc. (U.S.). Meanwhile, in the new pharmaceutical research and development area, American pharmaceutical companies at the top, too. As follows date to show. Even from the perspective of probability theory, supported by large-scale systematic research and development and huge funding, American pharmaceutical industry will not lose its dominant position in the short term. As follows (Table 1):

The paper wants to reiterate here is that the reason of two countries can keep their pharmaceutical industries safe. It is the objective situation and industrial demand of the two countries are different. American have to hold the head. That would make it attractive to global money to keep the industry development. On the contrary, China needs to limit international competition and use local resources to help the pharmaceutical industry. The concept of industrial security includes security and development [10]. In both cases, China and the United States have not clear failure.

4 Conclusion

The last required a bit of explanation that the paper aim to explain why the public can except the regulation mode in two countries, and the medical industries in these countries still maintain good development. If you use the economic model, you can see this. In the theory of domain about regulation:

$$\frac{C}{B} = \frac{\sum_{i=1}^{\infty} D_i}{S * P} \tag{1}$$

In this model, C means “Closed force polygon of Social”, B means “Institutional stability” (There are so many ‘S’s or ‘I’, so I use this letter.) D means “The number of Demands”, S means “Social Approval Degree”, P means “Path-dependence index”. It should be noted that the model is used to illustrate correlation.

On this basis:

$$S = O * A * T_1 \tag{2}$$

Table 1 Ranking of the world pharmaceutical companies

Rank	Company	Total revenue, 2015 (USD Million)	Annual revenue growth, 2014 to 2015 (%)	Revenue from pharmaceutical segment 2015 (USD Million)	Proportion of revenue from pharmaceuticals segment (%)	Total R&D expenses, 2015 (USD Million)
1	Johnson & Johnson (U.S.)	70,074	−5.73	31,430	44.85	9,046
2	Hoffmann-La Roche AG (Switzerland)	50,111	−3.50	38,855	77.54	9,972
3	Pfizer Inc. (U.S.)	48,851	−1.52	48,851	100.00	7,690
4	Novartis AG (Switzerland)	49,414	−5.30	30,445	61.61	8,935
5	Bayer AG (Germany)	51,407	−6.44	15,253	29.67	4,751
6	Merck & Co., Inc. (U.S.)	39,498	−6.48	34,782	88.06	6,704
7	Glaxo Smith Kline plc (U.K.)	36,566	−3.54	36,566	100.00	5,441
8	Sanofi (France)	34,542	8.99	34,542	100.00	5,082
9	Gilead Sciences, Inc. (U.S.)	32,639	31.13	32,639	100.00	3,014
10	Astra Zeneca plc (U.K.)	23,641	−9.40	23,641	100.00	5,997

$$P = \frac{T_2}{M} \tag{3}$$

In these models, O means "The public opinion", A means "The area of public opinion", and $T1$ means "The publicity time duration"; $T2$ means "The duration of the system (years)", M means "The number of system modification" (Tables 2 and 3).

It can be seen that the lower number of policy adjustments and the longer time of system exists, means the higher degree of path dependence. Therefore, it is more difficult to promote institutional reform. Correspondingly, the lower degree of social recognition and the shorter existence time of the system, means the less difficult the reform.

Table 2 The basic data of the world pharmaceutical companies

Rank	Company	Total expense ration, 2015 (%)	Total income ration, 2015	Total revenue from top. 3 pharmaceutical products, (%)	Proportion of revenue from top-3 pharmaceutical products, (%)	Revenue per employee, 2015 (USD Thousand)
1	Johnson & Johnson (U.S.)	72.61	21.99	11,266	35.84	551
2	Hoffmann-La Roche AG (Switzerland)	71.29	18.81	19,632	50.53	546
3	Pfizer Inc. (U.S.)	81.65	14.25	13,233	27.09	499
4	Novartis AG (Switzerland)	83.80	36.01	9,494	31.18	416
5	Bayer AG (Germany)	86.51	8.85	5,144	33.72	440
6	Merck & Co., Inc. (U.S.)	86.33	11.29	8,540	24.55	581
7	Glaxo Smith Kline plc (U.K.)	89.10	32.96	7,863	21.50	361
8	Sanofi (France)	84.64	13.06	10,038	29.06	299
9	Gilead Sciences, Inc. (U.S.)	32.00	55.48	22,599	69.24	4,080
10	Astra Zeneca plc (U.K.)	87.11	10.52	10,907	46.14	393

Data Sources SEC filings and annual reports

Table 3 Research and development investment of pharmaceutical enterprises [9]

International conglomerate	Research input (%)
JNJ (Johnson & Johnson)	31.00
Hoffmann-La Roche AG (Switzerland)	25.30
Merck & Co., Inc. (U.S.)	21.30
Eli Lilly and Company	19.80
NVS (Novartis)	19.40
Pfizer Pharmaceuticals Ltd.	17.30
Bayer AG	17.20
Glaxo Smith Kline plc	15.80
Sanofi-aventis	15.60
AstraZeneca	13.40

These models above cannot calculate the number. It shows the forms and relationships of the resultant forces. As the research moves along, there must be something new parameters to join.

We can use the formula of the degree of association between industrial competitiveness and industrial adaptation to verify the theory above [11].

$$C_i^m \sum\nolimits_{j=1}^{t} \frac{\eta_{ij}^m}{t} \tag{4}$$

In this equation, $i = 1, 2, \ldots, 12, m = 1, 2, \ldots 9, j = 1, 2, \ldots, t, C_i^m$ means the degree of association between industrial competitiveness and industrial adaptation, i means industrial competitiveness and m means industrial adaptation. So bringing the hi-techinnovation capacity and government control ability into this formula. It can be concluded that the correlation is constant, the higher one side, the lower the other. Take the United States as an example. As the Fig. 2 shown, if those six organizations plan to keep the local government or presidents' low control, they have to develop the science and technology.

In summary, although there were many similar objective conditions between China and the United States during their founding, the two countries have developed and formed two completely opposite modes in the aspect of regulation of the pharmaceutical industry due to the difference in some subtle parameters.

In addition, from the perspective of industrial safety, there is no apparent huge risk in current development of the pharmaceutical industries in China and the United States. More in-depth research is needed for assessing the safety index of the pharmaceutical industries in the two countries.

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Can Political Connection and Corporate Social Responsibility Affect the Information Disclosure Quality?

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Abstract Higher information disclosure quality of enterprises plays an important role in promoting capital marketization reform and optimizing financial service system. However, the research on how government-enterprise relationship and social responsibility affect the behavior choice of information disclosure is not sufficient, especially whether the fulfillment of corporate social responsibility can exert moderating effect on outward information disclosure quality under the existing social relations is still unknown. This paper takes the A-share mainboard listed companies of China's Shenzhen stock exchange from 2011 to 2016 as samples, and studies the relationship between political connection, corporate social responsibility and information disclosure quality based on the unique property rights differences of Chinese enterprises. It is found that, political connection is negatively related to information disclosure quality, while corporate social responsibility is positively related to information disclosure quality. The better the enterprise's social responsibility performance, the weaker the negative correlation between political connection and information disclosure quality. And further analysis shows that compared with state-owned enterprises, non-state-owned enterprises have a stronger negative correlation between political connection and information disclosure quality. Social responsibility performance of both types of enterprises can improve information disclosure quality. Meanwhile, social responsibility performance can also effectively suppress the negative impact of political connection on information disclosure quality.

Keywords Political connection · Information disclosure quality · Corporate social responsibility · Nature of property right

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1 Introduction

The report of the 19th National Congress of China Communist Party pointed out that it is necessary to deepen the reform of financial system and enhance the ability of financial services to the real economy. While information disclosure, as an important carrier to convey the development status and business performance of enterprises to external investors, is an important link between financial industry and business entities. Meanwhile, as an important factor affecting information asymmetry, information disclosure quality affects the resource allocation efficiency of the capital market and the transformation and upgrading of industrial structure to a certain extent.

Politics is an important external macro factor that affects corporate information disclosure behavior [1]. And compared with enterprises that rely on social relations to obtain resources, non-relational enterprises must have significantly different motivations for outward information disclosure based on considerations such as signal transmission and cost-benefit trade-offs. Although there is no unified definition of political connection (PC) in academia, most scholars agree that the government-enterprise relations should be taken as the starting point, and that such relations will provide a channel for the exchange of resources and information between the two [2]. Simultaneously, premier Keqiang Li emphasized the political leadership as the primary task and vigorously promoted enterprises, especially private ones, to better fulfill their social responsibilities at the 12th National Congress of All-China Federation of Industry and Commerce. Good corporate social responsibility (CSR) performance not only has a positive effect on social poverty alleviation, but also helps to improve CSR information disclosure level and capital allocation efficiency [3–5].

Previous studies have shown that both CSR and PC have an impact on corporate information disclosure decisions. However, such studies only discuss the two in isolation, in practice, many enterprises not only increase the investment in government-enterprise relations but also implement the social responsibility behavior. Then, what is the difference between the influence effect of PC and CSR performance on corporate information disclosure quality (CIDQ)? Is there a promotion or inhibition relation between the two? What impact does the special property right of Chinese enterprises have on this relationship? Based on this, this paper takes the 2011–2016 A-share mainboard nonfinancial listed enterprises of Shenzhen as samples to test the interactive effect of CSR performance and PC on outward CIDQ, and to investigate the influence of property right difference on the mutual effect.

2 Literature Review

Many papers have studied some important factors affecting the CIDQ of Chinese enterprises. It mainly includes the external environment of enterprises such as legal system and degree of investor protection, and the internal environment such as corporate governance and financial performance and so on [6–9].

Some scholars have found that as an important resource advantage of enterprises, PC will not only affect their business activities, but also have an impact on CIDQ [1, 10]. Cheng and Wang found that although PC can influence enterprises to more actively disclose environmental information, it may also cover up political rent-seeking under the guise of environmental protection, which is particularly common among state-owned enterprises [11]. Ren and Wang found that the CIDQ of annual report of relation-based enterprises is significantly lower than that of other enterprises, and the split share reform has alleviated this effect to some extent [12].

However, few scholars have studied the impact of CSR performance on CIDQ, especially whether and how CSR can influence the relationship between PC and corporate information disclosure decision, are still lacking enough attention and due analysis. Wang, Ji and Shi found that CSR has a positive impact on the timeliness of annual report disclosure. The better the social responsibility is performed, the higher the efficiency of information interpretation by its investors [13]. Feng and Song found that both the establishment of PC and the fulfillment of CSR by Chinese private enterprises are conducive to promoting diversified investment of enterprises. What's more, the better the enterprises perform their CSR, the stronger the role of facilitating diversification strategy through PC [14]. This paper puts enterprises' two kinds of behaviors, namely seeking government-enterprise contact and fulfilling social responsibility under the same framework to discusses their influence on comprehensive information disclosure quality of enterprises, so as to makes up for the deficiencies of existing research.

3 Theory and Hypothesis

3.1 The Impact of PC on CIDQ

Establishing PC is often a double-edged sword. Firstly, PC is an alternative mechanism that can effectively compensate for the defects of formal system. By actively seeking benign interaction with government, it can bring public subsidies, tax incentives and ease financing constraints for enterprises, then reduce the possibility of asset being invaded and expand the M&A for the purpose of policy arbitrage [15, 16]. Secondly, from motivation perspective, PC have increased the sensitivity of related managers to changes in external environment, making them lack of urgent motivation to actively release information [17]. According to signaling theory, the allocation of resources held by government under PC is opaque, which is often the result of interests' exchange between specific enterprise and government. This hidden transaction makes it possible for enterprises to make selective or whitewash disclosure. Meanwhile, in order to avoid external supervision and public attention, executives with government background are often strongly motivated to reduce information transparency, which in turn affects CIDQ [10, 18]. From cost perspective, higher relationship maintenance costs are implied behind PC. Although enterprises can gain benefits from it, they must pay corresponding rents. According to redundant resources theory, when enterprises need to use more energy and resources to hire official-type-executives, pay more salaries and maintain government-enterprise relations, they will face greater cost pressure. Correspondingly, they will reduce their investment in internal governance and various statements' preparation, then the performance in outward information disclosure may also be poor. Therefore, the following hypothesis is proposed in this paper.

Hypothesis 1: enterprises with PC have lower CIDQ.

3.2 The Impact of CSR on CIDQ

Well-performing enterprises have incentives to deliver high levels of corporate information. Firstly, based on legality theory and corporate citizenship theory, enterprises should bear legal and moral responsibility while undertaking economic responsibility. Hong and Andersen found that the stronger the CSR, the higher quality of its accrued profits and the less behavior of real earnings management [19]. Therefore, based on their true pursuit of legal status and moral obligation, responsible enterprises can voluntarily abide by the provisions of accounting standards and provide stakeholders with financial and nonfinancial reports with strong relevance to accounting information, so as to improve outward CIDQ and achieve "communication effect" [20]. Secondly, based on information asymmetry theory and reputation benefit, the fulfillment of CSR is an important basis for investors to analyze and judge the formulation and implementation of corporate strategy, which helps to avoid the mismatch of market resources caused by adverse selection problem [21]. The disclosure of CSR information effectively reduces information asymmetry between stakeholders and enterprises, and to some extent remedies for the incomplete defects in financial report information [22]. Meanwhile, enterprises with good CSR are more willing to disclose their CSR reports in order to conduct impression management through information disclosure, gain trust and recognition from government, consumers and investors, and form great reputation to reduce their transaction costs. In turn, investors are urged to make decisions that support corporate profit targets, thus reducing the risk of incomplete information disclosure. Therefore, the following hypothesis is proposed in this paper.

Hypothesis 2: enterprises with better CSR performance have higher CIDQ.

3.3 The Moderating Effect of CSR on the Relationship Between PC and CIDQ

According to resource dependence theory, government is a key external resource for enterprises, and its development arrangement of industrial structure and allocation choice of social resources affect the survival and development of enterprises. Therefore, enterprises need to actively build close ties with government, cater to its needs and undertake part of the economic, political and social tasks for it [23]. In view of its own political achievements and promotion, government also introduce corresponding policies to stimulate enterprises in its jurisdiction to actively fulfill CSR. Accordingly, the more CSR enterprises perform, the more they can convey to government the signal of behave well and response positive, then gaining more attention and favor, obtaining more key resources, information and political asylum, and reducing operating costs. Therefore, enterprises have a tendency to establish and maintain government-enterprise relations by practicing CSR [24]. Firstly, information disclosure is an important performance of enterprises to fulfill their CSR. Enterprises with good sense of CSR tend to take the initiative to fulfill their information disclosure obligations to ensure the accuracy and timeliness of disclosure. Chen, Liu and Lu found that enterprises with PC at central-government level are not only more likely to issue CSR reports, but also have higher reporting quality [25]. Secondly, according to stakeholder theory, actively fulfilling CSR can help build harmonious and win-win corporate cultures and pluralistic and co-governance models, then inspire each contract subject to strengthen the supervision of CIDQ, purify internal information environment, and guide PC to develop in a healthy direction, ultimately improve the attention of managers with PC to CIDQ. Therefore, the following hypothesis are put forward.

Hypothesis 3: good CSR performance can weaken the inhibition of PC on CIDQ.

4 Methodology and Data

4.1 Data

Although both Shenzhen and Shanghai Stock Exchange evaluate the information disclosure of listed companies, only Shenzhen publishes the assessment results on its website. Therefore, this paper selects the 2011–2016 A-share mainboard listed companies in Shenzhen as initial research samples, and filters the data according to the following criteria. Excluding financial and insurance industry, ST and *ST enterprises, and eliminating enterprises with missing data or unclear disclosure. In this paper, CSR performance data are derived from the Chinese financial-news site Hexun's professional score, PC data are organized by manually collecting background information of executives, CIDQ rating data are obtained from Shenzhen's website, and other financial data come from the CSMAR database. Continuous variables with outliers are subjected to Winsorize processing on 1% and 99% quantiles.

4.2 Variables

The explained variable is corporate information disclosure quality (CIDQ). Based on the quantitative index system constructed from information disclosure, standard operation, regulatory measures and violation punishment, Shenzhen evaluates the information disclosure of listed companies, and classifies them from high to low into four grades, namely A (excellent), B (good), C (qualified) and D (unqualified) according to CIDQ. Therefore, the annual rating on enterprises' information disclosure directly reflects their CIDQ, which can overcome the limitations of using earnings manipulation, analyst prediction accuracy and violations as proxy variables for CIDQ [26]. This paper defines four types of sequence variables, that is, the CIDQ of enterprises is assessed as excellent with a value of 4, good with a value of 3, qualified with a value of 2, and unqualified with a value of 1. The lower the value, the lower the CIDQ.

The first explanatory variable is political connection (PC). The existing literature focuses PC on two key positions, chairman and CEO (or general manager), but this paper extends the research to executive team. Drawing on existing research, if corporate board members (excluding independent directors) or managerial executives have one of the following conditions, it is considered that the enterprise has PC [24]. Firstly, present or former officials of government departments, such as party committees (including discipline inspection commissions), governments, courts and procuratorates. Secondly, current or former members of party representatives, deputies to the NPC or CPPCC. This paper sets the binary discrete variable. If the enterprise has PC, the value is 1, and if there is no PC, the value is 0.

The second explanatory variable is corporate social responsibility (CSR). The Chinese financial-news site Hexun establishes a professional evaluation system for CSR of listed companies. It integrates CSR report and annual financial report data issued by enterprises, and comprehensively evaluates CSR behavior from five aspects, namely, shareholder responsibility, employee responsibility, supplier, customer and consumer rights responsibility, environmental responsibility and social responsibility. This paper uses the CSR score published on the website as the proxy variable for CSR. The higher the score, the better the CSR performance.

Considering other factors that affect CIDQ, this paper introduces some control variables, details are as follows. In addition, industry (Ind) and year (Year) dummy variables are controlled.

Enterprise scale (Size). The larger the scale of the enterprise, the more attention it will receive from the public and regulators, making it passively improve CIDQ. Measured as the natural logarithm of year-end total assets. Financial leverage (Lev). The higher the leverage ratio, the higher the debt level and the worse the solvency, which may enhance the possibility of whitewashing statements and earnings management. However, it may also face strict supervision by creditors, then making corporate information disclosure more complete. Measured by asset-liability ratio. Growth ability (Grow). When the growth of enterprise is good, executives are more willing to pass on information to external investors that is beneficial to corporate value, then improving CIDQ. Measured by sales revenue growth rate. Corporate profitability (ROA). The stronger the enterprise's profitability, the more incentive it has to convey the signal of good business performance to outside world, and increase resources' input in information disclosure, CIDQ will improve accordingly. Measured by return on total assets.

Equity structure (Fishare). Measured by the largest shareholder's shares proportion in total shares. The higher the ratio, the stronger the control of it. In order to maximize its interests, it either may support executives' information manipulation to mislead investors, or may strengthen the supervision of executives' behavior to realize the synergy with enterprise's interests. Equity concentration (Central). Measured by the square sum of shareholding ratios of top ten shareholders. The smaller the index, the more balanced the distribution of rights among top ten shareholders, that is, the equity is relatively dispersed, otherwise, the more obvious the absolute controlling advantage of major shareholders. Board size (Board). Smaller board has comparative advantages in information communication and lower coordination and organization cost, which is conducive to alleviating principal-agent problems under information asymmetry then restraining the opportunistic behavior of the board [27]. Measured by the end-year total number of board members. Independent director supervision (Indep). Independent directors are less related to executives. The greater the number of them on the board, the stronger the independence and supervision of the board, and the higher the level of voluntary information disclosure. Measured by the proportion of independent directors in the board.

Audit authority (Big4). Audit institutions assume supervisory responsibility for CIDQ. High-quality external audit represented by "international big four" can improve the information disclosure degree of enterprises and better exert the corporate governance effect of external audit. Measured as whether the audit institution is big4. If it is, the value is 1, otherwise the value is 0. Nature of Actual Controller (SOE). Define a binary dummy variable, which takes the value of 1 if the enterprise is state-owned and 0 if it is non-state-owned.

4.3 The Econometrics Model

Drawing on existing research, this paper builds (1) to study the impact of PC on CIDQ, builds (2) to examine the impact of CSR performance on CIDQ, and finally adds the interactive item of CSR performance and PC based on (1) to test the moderating effect of CSR on the relationship between PC and CIDQ [14, 28]. The specific measurement models as shown in (1), (2) and (3).

$$CIDQ_{it} = \alpha_0 + \alpha_1 PC_{it} + \sum \beta\, Control_{it} + \epsilon_{it} \tag{1}$$

$$CIDQ_{it} = \alpha_0 + \alpha_1 CSR_{it} + \sum \beta\, Control_{it} + \epsilon_{it} \tag{2}$$

$$CIDQ_{it} = \alpha_0 + \alpha_1 PC_{it} + \alpha_2 PC_{it} \times CSR_{it} + \sum \beta\, Control_{it} + \epsilon_{it} \quad (3)$$

Where i denotes the corporate, t denotes the year, α_0 denotes the intercept item, α_1, α_2 and β denotes regression coefficients, *Control* denotes a series of control variables, ε_{it} is the random error term. If the PC coefficient of (1) is significantly negative, then hypothesis 1 is proved. If the CSR coefficient of (2) is significantly positive, then hypothesis 2 is proved. In addition, if the coefficient of interaction term in (3) is significantly positive, hypothesis 3 can be verified.

5 Results

5.1 Descriptive Statistics and Correlation Analysis

Table 1 is the descriptive statistics of main variables. The average value of CIDQ is 2.957, and the median is 3, indicating that the CIDQ of listed companies is at a good level on the whole. The average value of PC is 0.622, indicating that more than 60% of the enterprises in the sample have established some form of PC, that is, political connection is common among Chinese listed companies. The average score of CSR performance is 49.141, and the standard deviation is 22.062, which indicates that the overall situation of listed companies in CSR is not optimistic, and there are great differences in CSR performance among different enterprises. According to Pearson correlation analysis of main variables, CIDQ is significantly negatively correlated with PC and positively correlated with CSR at the 1% level. Hypothesis 1 and 2 are

Table 1 Descriptive statistics of variables

Variables	Num	Mean	Med	Std. Dev.	Min	Max
CIDQ	2278	2.957	3.000	0.627	1.000	4.000
PC	2278	0.622	1.000	0.382	0.000	1.000
CSR	2278	49.141	57.615	22.062	−15.110	90.870
Size	2278	23.109	23.010	1.442	19.197	28.508
Lev	2278	0.515	0.523	0.206	0.070	1.702
Fishare	2278	0.344	0.306	0.163	0.081	0.790
ROA	2278	0.037	0.035	0.068	−0.242	0.295
Big4	2278	0.149	0.000	0.356	0.000	1.000
Board	2278	9.315	9.000	1.999	4.000	18.000
Indep	2278	0.374	0.363	0.059	0.281	0.566
Central	2278	0.196	0.170	0.135	0.003	0.799
Grow	2278	0.125	0.079	0.569	−0.882	4.647
SOE	2278	0.632	1.000	0.483	0.000	1.000

preliminarily verified. The correlation coefficient between all variables is less than 0.6, and the highest correlation occurs between Fishare and Central, which is 0.573. Further VIF analysis is performed for the regression model. The VIF values of each variable are lower than the empirical critical value 10, indicating that there is no serious multi-collinearity problem in models.

5.2 The Impact of PC and CSR on CIDQ

The regression results in Table 2 are the separate effects of PC and CSR on CIDQ and the interaction between the two. It shows in (1) that the regression coefficient between PC and CIDQ is −0.114, which is significant at 1% level, indicating that PC has an adverse impact on CIDQ. The CIDQ of listed companies with PC are significantly lower than that of listed companies without PC, so hypothesis 1 can be proved. It shows in (2) that the regression coefficient of CSR performance is significantly positive at 1% level, indicating that listed companies with good CSR performance are more motivated to disclose information, then CIDQ increases accordingly, so hypothesis 2 is verified. After adding the interaction between PC and CSR performance, the coefficient of PC in (3) is still significantly negative, but the coefficient of interaction term is significantly positive at 1% level, indicating that although PC can reduce the CIDQ, good CSR performance of listed companies will enhance the willingness of relational executives to highlight their contribution to political achievements, weaken the negative effect of PC on CIDQ, and improve the CIDQ of politically connected enterprises. It is proved that under the current political and economic environment in China, incorporating CSR into corporate strategy can play a positive role in promoting CIDQ. Hypothesis 3 is verified.

5.3 The CIDQ of Different State of Ownership

The nature of property rights promotes the differences in the business practices of Chinese enterprises, and is also an important factor affecting enterprises to formulate CSR strategies and seek political asylum.

This paper further differentiates state-owned enterprises from non-state-owned enterprises for grouping test. As shown in columns 1 and 4 of Table 3, the PC of state-owned enterprises is negatively correlated with CIDQ, but the coefficient is not significant. The coefficient between PC and CIDQ of non-state-owned enterprises is significantly negative at the level of 5%, indicating that the existence of PC has a stronger impact on CIDQ in non-state-owned enterprises. Columns 2 and 5 of Table 3 show that CSR performance of both state-owned and non-state-owned enterprises is significantly positively correlated with CIDQ, and the CSR performance of state-owned enterprises has a greater influence coefficient on CIDQ. As shown in columns

Table 2 The impact of PC and CSR on CIDQ

Exp-var	Model (1)	Model (2)	Model (3)
PC	−0.114*** (−2.78)		−0.498*** (−5.18)
CSR		0. 315*** (14.27)	
PC × CSR			0.428*** (4.45)
Size	0.098*** (4.89)	0.081*** (3.67)	0.100*** (5.02)
Lev	−0.622*** (−4.78)	−0.508*** (−3.69)	−0.635*** (−4.89)
SOE	0.015 (0.31)	0.083* (1.77)	0.044 (0.93)
Fishare	0.003 (0.73)	0.009* (1.85)	0.018*** (3.74)
Big4	0.141** (2.21)	−0.051 (−0.75)	0.083 (1.27)
ROA	1.849*** (4.48)	1.836*** (4.45)	1.172*** (2.84)
Grow	0.134** (2.29)	0.123** (2.01)	0.313*** (5.36)
Indep	0.116 (0.32)	0.658* (1.82)	3.350*** (9.28)
Board	−0.021** (−2.30)	−0.016 (−1.52)	−0.018* (−1.93)
Central	−0.720 (−1.35)	−1.117** (−2.10)	−0.721 (−1.36)
Con	−0.842* (−1.85)	−0.779* (−1.81)	−4.711*** (−10.89)
Ind/Year	Control	Control	Control
Num	2278	2278	2278
Adj-R2	0.135	0.138	0.312
F Value	28.32***	28.98***	69.42***

*Remarks: t statistics in parentheses: *p < 0.1, **p < 0.05, ***p < 0.01*

3 and 6 of Table 3, CSR performance of both state-owned enterprises and non-state-owned enterprises can weaken the negative impact of PC on CIDQ. It shows that the information spillover effect of enterprises fulfilling CSR is obvious.

Table 3 Distinguishing the state of ownership

Exp-var	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
	SOE = 1			*SOE = 0*		
PC	−0.042 (−0.75)		−0.155* (−1.69)	−0.143** (−2.05)		−0.769*** (−5.52)
CSR		0.322*** (8.59)			0.153*** (6.95)	
PC × CSR			0.121*** (6.14)			0.102*** (5.17)
Size	0.102*** (3.90)	0.112*** (4.61)	0.115*** (4.69)	0.076*** (2.92)	0.059** (2.43)	0.117*** (4.74)
Lev	−0.465*** (−2.65)	−0.555*** (−3.41)	−0.558*** (−3.87)	−0.457** (−2.46)	−0.541*** (−3.28)	−0.566*** (−3.94)
Grow	0.189 (1.22)	0.061 (0.80)	0.268* (1.73)	0.197* (1.66)	0.067 (0.86)	0.306*** (2.94)
ROA	2.063*** (3.71)	0.093* (1.70)	1.133** (2.24)	1.598*** (2.61)	0.092* (1.69)	1.089* (1.91)
Board	−0.029** (−2.04)	−0.021 (−1.61)	−0.026** (−1.97)	−0.023 (−1.59)	0.017 (1.01)	−0.048** (−2. 09)
Indep	−0.027 (−0.45)	0.057** (2.36)	0.051* (1.94)	0.086 (0.82)	0.046* (1.92)	0.194*** (3.26)
Fishare	0.021*** (2.82)	0.027*** (3.05)	0.014** (2.01)	0.012 (1.23)	0.018** (2.34)	0.020*** (2.77)
Central	−0.074 (−1.01)	−0.124* (−1.69)	−0.087 (−1.19)	−0.006 (−0.89)	−0.133** (−1.99)	−0.093 (−1.27)
Big4	0.313*** (4.04)	0.110* (1.66)	0.194** (2.51)	0.106 (1.36)	0.149* (1.93)	0.137* (1.75)
Con	−1.498* (−1.82)	0.024 (0.46)	−1.760** (−2.19)	−1.393* (−1.68)	1.554* (1.93)	−1.563* (−1.94)
Ind/Year	Control	Control	Control	Control	Control	Control
Num	1441	1441	1441	837	837	837
Adj-R2	0.165	0.179	0.232	0.131	0.164	0.243
F Value	17.02***	18.47***	24.55***	13.52***	16.98***	25.94***

*Remarks: t statistics in parentheses: *p < 0.1, **p < 0.05, ***p < 0.01*

5.4 Robust Check

In order to ensure the robustness of the regression results, this paper also carries out the following tests. Firstly, CIDQ belongs to discrete ordered dependent variable, then further constructs the sequential multi-classified Ordered Logistic regression model (4) for regression analysis.

$$
\begin{aligned}
OrderedLogist(\mathrm{P}) &= \mathrm{P}(CIDQ = 1/2/3/4) \\
&= \alpha_0 + \alpha_1 PC_{it} + \alpha_2 PC_{it} \times CSR_{it} + \sum \beta\, Control_{it} + \epsilon_{it}
\end{aligned}
\tag{4}
$$

Secondly, this paper defines the dummy variable (CIDQ2) about the quality of corporate information disclosure. When the enterprises' information disclosure rating is A and B, the value is 1, otherwise it is 0. Logistic regression model (5) is constructed for regression analysis.

$$\begin{aligned} Logist(\mathrm{P}) &= \mathrm{P}(CIDQ2 = 1) \\ &= \alpha_0 + \alpha_1 PC_{it} + \alpha_2 PC_{it} \times CSR_{it} + \sum \beta\, Control_{it} + \epsilon_{it} \end{aligned} \tag{5}$$

Table 4 regression results show that the coefficients of the two interaction terms are still significantly positive at the level of 1%. It shows that the conclusion that

Table 4 Robustness check

Exp-var	Ordered logistic model (4)	Logistic model (5)
PC	−0.342*** (−3.98)	−0.146* (−1.71)
PC × CSR	0.106*** (3.52)	0.502*** (5.84)
Size	0.154* (1.82)	0.392*** (4.62)
Lev	−0.588*** (−4.64)	−0.469*** (−3.72)
Big4	0.077 (1.21)	0.103 (1.62)
SOE	0.053 (0.61)	0.151* (1.86)
ROA	0.712* (1.77)	0.917** (2.33)
Grow	0.117** (2.47)	0.173*** (3.59)
Board	−0.490 (−1.58)	−0.298 (−1.03)
Indep	0.235*** (2.67)	0.254*** (2.88)
FirShare	0.203** (2.31)	0.156* (1.73)
Central	−0.120 (−1.35)	−0.114 (−1.28)
Con	−1.883** (−2.05)	−3.98*** (−4.37)
Ind/Year	Control	Control
Num	2278	2278
Chi2	179.30***	217.41***
Pseudo-R2	0.115	0.132

*Remarks: z statistics in parentheses: *p < 0.1, **p < 0.05, ***p < 0.01* the implementation of CSR strategy can help alleviate the negative impact of PC on CIDQ is of certain robustness.

6 Conclusion

Through panel data at the listed company level in China's Shenzhen A-share mainboard from 2011 to 2016, this paper uses three types of econometric models to test the effect of the implementation of political connection strategy and social responsibility strategy on corporate information disclosure quality.

It is found that PC exert a negative impact on CIDQ. Enterprises with politically connected executives tend to hide part of information while gaining government support, and the CIDQ is relatively low. CSR is positively related to CIDQ. Enterprises with good CSR performance are more willing to release effective information about their business activities to capital market and the information transparency is relatively high. Further analysis shows that good CSR performance can effectively inhibit the negative impact of PC on CIDQ, which indicates that government's measures to encourage micro-enterprises to fulfill their CSR and feedback macro-economy have played a policy effect in recent years. In addition, under the "dual" economic system in China, the negative relationship between PC and CIDQ is more pronounced in non-state-owned enterprises. CSR plays an important role in improving CIDQ under the two types of property rights. Meanwhile, whether state-owned or non-state-owned enterprises, their good CSR performance have the efficacy of weakening the negative impact of PC on CIDQ. According to the empirical results, improving the level of CSR performance not only contributes to optimize CIDQ, but also plays an active role in regulating the power of executives with PC on corporate information disclosure decisions.

Therefore, under the current unique "relational" economic environment in China, CSR can serve as a link between enterprises' maintenance of social capital and government's practice of reforming the securities regulatory institutions. Government should include CIDQ in the performance assessment of enterprises with PC and strengthen the requirements for the behavior of CSR and information disclosure in the process of industrial support and industrial restructuring. Enterprises should incorporate CSR and PC into corporate strategy, strategically apply the signal-transfer advantages of CSR and its interaction with PC. External investors should attach importance to the supervision of CIDQ of enterprises with PC and the requirements for good CSR performance. It can play a positive role in promoting the effective use of the capital market information disclosure institution and improving the efficiency of resource allocation in the whole industry chain.

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An Improved Model for Efficiency Evaluation on Energy Industry

Zhen Li and Yingqi Liu

Abstract The development and growth of human beings are highly depended on energy consumption. Nowadays, the sustainable development of human beings calls for precisely speculation of energy prices and efficiency. However, the traditional methods of measuring energy price and efficiency, for instance, the EROI (energy return on investment) model unable to define system boundaries and to calculate labor and physical costs. Thus, these methods may ignore as much as 50% of input energy consumption. Energy efficiency could be calculated by the ratio of average energy input cost to the average useable energy output cost while energy price could be measured by the ratio of the monetary input to the output. The principle above could be viewed as a check for energy return on investment as well as an elimination for a redundant process analysis. The results give us a chance to innovate traditional energy efficiency model by social and environmental factors which could be depicted through monetary terms.

Keywords Energy efficiency · EROI · Improved model

1 Introduction

Energy plays a vital role in economic development [1]. The significance of renewable energy has becoming more and more important as the ongoing fossil resources consumption. Gupta and Hall [2], warned this issue in the paper. What's more, Hall, Lambert and Balogh [3] reckon to increase the significance of energy efficiency (EE) and reduce the usage of EROI in fossil resources extraction. Although we have

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entered a new era of renewable energy, whereas it is still hard for us to find out whether these energies from solar cells, fission, tidal plants, windfarms could feed the needs of human economic development. Photovoltaic (PV) energy has become a complementary energy in China for electricity distribution. On the contrary, biodiesel, corn-based ethanol and PV farms are reported to have energy return on investment >1 [4, 5], such conflicting conclusions require an further explanation.

Therefore, because human beings' development relies heavily on the energy accessibility, this give us an opportunity to precisely project energy production efficiency [6], scholars attempts to create new economic model for measuring energy price and efficiency has never ended. Till now, all of the attempts for linking EE and economics have failed to achieve satisfied results. Murphy, Hall [7] demonstrate monetary return on investment to EROI, whereas they get ambiguous results. Herendeen [8] utilizes a two-stage I/O model to obtain some results to the linkage from prices to EE. Unluckily, the model he proposed also has limitations which like the traditional EROI model does: system boundaries as well as classification problems [7, 8]. This, in a nutshell, simply means the main energy inputs which are eventually the buildings and machinery, are typically included in the system boundaries. Therefore, those boundaries indirectly restrict the computation of energy expenditure. Since the energy return on investment is constantly derived ex-ante, relevant consumptions are necessary for inputs energy intensity and the input variables need to be obtained in O/I data base. Whereas, during calculation process, some conditions (for instance, specific building design or transportation) might be remarkably different with the I/O data available in databases. In this paper, we will demonstrate economics could be an effective method when measuring energy efficiency.

This paper is based on the hypothesis that energy is the ultimate production factor compared with other factors (capital, labor) [1, 9–11], or [12]. Without considering the system boundaries, the ratio of energy input and output costs (energy cost ratio ¼ ECR) approximates the energy return on investment (EROI). Considering the system boundaries, energy change rate is better than energy return on investment. Since some costs are intangible, I/O energy price ratio is constantly utilized for substitution although that could demand the rental shares in the input and output energy prices to be similar. We would like to find out a general method to describe the mathematical relation between energy efficiency and prices, the method shown in this paper requires further extensions and empirical examination. This paper explains the relation between energy prices and energy return on investment, follow with the discussion and conclusion of recent development on energy assessment methods and models.

2 Traditional Energy Efficiency Model

Since the production process is extremely complex, thus the problem of energy return on investment is that it is virtually impossible to define all the fundamental inputs. However, in order to fully describe input energy, energy return on investment requires:

$$\text{EROI} = \text{useful output energy} / \text{input energy}$$

This raises a problem: Does energy return on investment includes the energy consumed in heating system, transportation and so on by the employees in energy production process? Unfortunately, the answer is definitely not. Thus, traditional methods for energy return on investment tend to omit some of inputs, on the contrary, the output factors are very clear to be identified. Murphy and Hall [13] demonstrate that, for oil/diesel and corn-based ethanol, the results calculated through using traditional energy return on investment is remarkably higher than the results derived from model considering intangible cost, for example, the construction costs of vehicles and roads [13]. To solve the problem, they speculate that the minimum energy return on investment contributed to transportation is around 3:1, then they utilize it to offset the corn-based ethanol energy return on investment to 1.3. The conclusion which Murphy and Hall made in the paper is that it is extremely hard to fully figure out and calculate energy return on investment and its effects.

Chu and Majumdar [14] write a paper on levelized cost of energy. They found that wind, within all renewable resources, hydro and geothermal could be cheaper compared with fossil resources. Therefore, actually some so-called sustainable energies are more expensive than traditional fossil resources despite lots of scholars reckon renewable energies are more efficient and effective. Chu and Majudmar's [14] make an estimation on energy price: The levelized cost of energy of nuclear power, coal-fired plants and combined cycle gas turbine is half the PVs'. Since the price is high, therefore for most European countries, they have to subsidize photovoltaic electricity (stipulate the obligation of distribution and transmission companies to buy out the PV electricity at rigid prices or subsidize the PV energy producers with "green bonuses"). Through extended calculation, Tao et al. [5] measured the ratio of non-renewable energy investment to energy delivered of photovoltaic plant in China. Ferroni and Hopkrik make a systematic estimation using intangible labor cost into energy return on investment calculation, the results show photovoltaic EROI in Swiss is approximately 1, close to the ratio NEIED = 0.95 in the 1st China's photovoltaic tower.

Tao et al. [5] discoveries a fruitful result in his paper: when considering energy displacement credits, the EROI of second-generation biofuels is up to 2.7, on the contrary, the figure could reduce to up to 1.5 without considering such credits. The ratio of 1.5 MJ gain per 1 MJ spent (or 50% net gain) is considerably inefficient. Firrisa, Duren, and Voinov [15] make a thorough calculation on the energy inputs (shown as Fig. 1), the results show the extended return on energy investment for rapeseed biodiesel production process is at least 1.7.

However, economists hold different views on this matter. According to the U.S. energy information administration, the prices of all grades conventional retail gasoline prices are from \$2 to \$3 per gallon in 2016 and 2017, the ethanol-gasoline blend E85 has been more expensive than gasoline in the U.S., shown as Fig. 1. Since the advent of electric vehicles, electricity has become the cheapest propulsion fuel, the cost of using electricity is 4 times cheaper compared with using biodiesel. According to some studies, the energy return on investment of biodiesel could reach to as high as

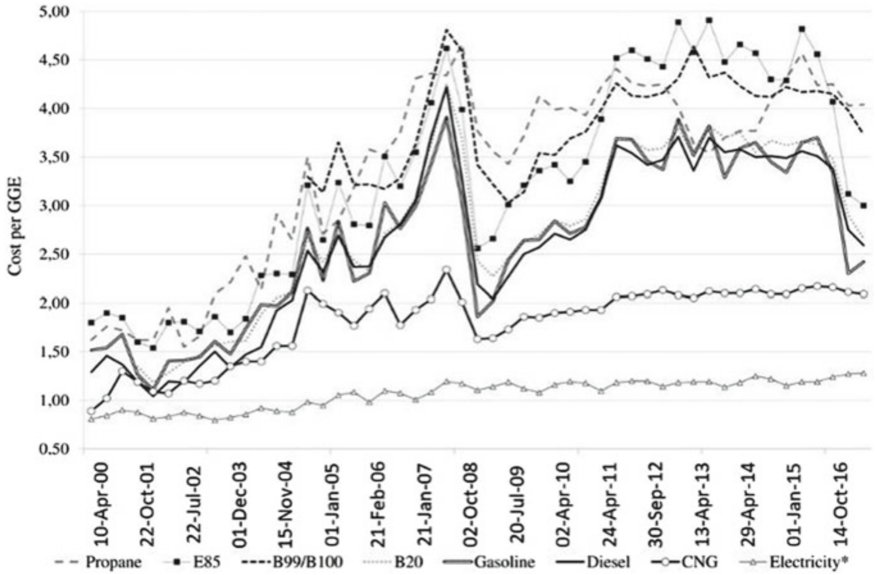

Fig. 1 Fuel prices in the USA; *source* AFDC, 2018

2, although most of inputs to liquid biofuel production are cheaper than liquid biofuel. On the other hand, it’s quite interesting that Murphy, Hall and some other scholars calculate in their papers that the energy return on investment of liquid biofuels is below 1. This leads us to consider two questions:

Firstly, why the isobutene is at least as expensive as gasoline, are the energy return on investment of such biofuels 1.5 at their worst? Secondly, what’s the price for biofuel production and how to measure it?

The first question could be solved by summating the total energy consumption in the whole biofuel production process. The second question is much more complicated since it needs precise calculation on the quantities and prices of energy consumption in the biofuel production process. The production process involves large amount of procedures and details; therefore, it is extremely difficult to conclude all of the production factors in the model. In the production process, even the employees’ rest could cause energy consumption, the calculating results could be affected if such energy consumption is ignored in the modeling process. Yang et al. [16] obtain an opposite result to Tao et al. Yang’s paper argues that the corn-based ethanol production in China is strongly unsustainable if the net cumulative energy consumption of each nonrenewable input is considered in calculating process.

These ambiguous results give us an opportunity to extend the traditional energy efficiency measuring model and precisely calculating the real energy efficiency using innovative economic model.

3 Literature Review on Energy Efficiency Measurement Methods

3.1 Energy Efficiency Models

Some scholars use extended energy return on investment model which includes lots of input factors as much as possible, such method lack necessary simplification (Lambert [6]). While at the same time, it is virtually impossible to simulate the whole production process due to the complexity of whole production process, especially when the process meets with intangible input factors. Bhandari presents the view on EROI assessment in his paper: "Full life cycle energy would have been more accurate but is not currently feasible to include in this systematic review due to lack and discrepancy of data regarding transportation, operation and waste management life cycle stages." In terms of production process, there are too many input factors need to be considered when calculating energy return on investment, which factors should be included in the calculation process which should not be requires the scholar's cautious analysis. What's more, according to Rugani and Benetto, any attempt to calculate emergy (input energy) is necessarily "missing most of the connections and interactions occurring between processes of the system resulting in a fewer comprehensive data inventory" [17].

Thus, the use of complicated energy efficiency assessment model, for instance the cumulative estimates model, has been facing increasing pressure. Whereas, Arvesen [18] discoveries few weaknesses of cumulative estimates model:

> "Life cycle analysis could be utilized for calculating energy return on investment, but it is difficult to define the system boundaries and the classification of energy factors."

> "Supply chain losses included in life cycle analysis need to be adjusted for when calculating energy return on investment."

Besides, data envelopment analysis is often utilized in the calculation of energy efficiency, but it faces the problem of identifying intangible input factors as well, for instance labor and capital, which make the assessing process complicated. Some extended energy return on investment calculations include labor and capital into the model, but the results are still unsatisfying. Another extended model is the non-renewable energy investment in energy delivered (NEIED), which concentrate the role of non-renewable inputs. It utilized the ratio of non-renewable energy spent on production of energy to volume of that production as the result. Unfortunately, this model also has drawbacks, Chen presents in his paper that the NEIED of windmill is below 0.5 in China, and despite the buyout of wind utility buyout is control by government. Besides, the backup cost during the production process is not included in the calculation. Therefore, NEIED still does not take indirect cost into consideration.

3.2 The Relationship Between Price and Energy Efficiency

Many scholars have been trying to solve the link between energy efficiency and energy price. King and Hall [19] have found some fruitful relationship between EROI and energy price, they found monetary return on investment has close relationship with energy return on investment despite their discoveries fail to resolve the core problem, the relationship they have found is as follow:

$$EROI = MROI \frac{\sum_{i=1}^{M} m_i e_i}{\sum_{i=1}^{M} m_i p_i} \frac{\sum_{i=1}^{N} n_i p_i}{\sum_{i=1}^{N} n_i e_i} \tag{1}$$

$$EROI = \sum_{i=1}^{M} m_i e_i \text{ or } EROI = \sum_{i=1}^{N} n_i e_i \tag{2}$$

$$MROI = \sum_{i=1}^{M} m_i p_i \text{ or } MROI \sum_{i=1}^{M} n_i p_i \tag{3}$$

In the formula, mi represents the quantity of output energy product, e_i represents for the energy content of output/input, n_i represents for the quantity of LCA based input pi is the price per input/output unit. Since $\sum_{i=1}^{M} n_i p_i$ is equal with $investment in (3) and the $investment is included in (3), so here the MROI is defined indirectly. Therefore, by making necessary adjustments, (2) means $1 = 1$, however, this method is unable to figure out the link between prices and energy efficiency.

Basically, all of the methods for calculating energy efficiency should obtain similar results. Whereas, in reality, since the original data and the computational methods are different, it is almost impossible to obtain the same result. Thus, the real energy cost could probably be underestimate through using current energy efficiency assessment methods, be it EROI, EMROI or P-LCA, which finally leads to overestimation of energy efficiency.

4 An Improved Model

First, we define useful output quantities as $Q_i = [q_1, q_2 \ldots q_m] \in R^{M_i}, i \in \{0 \ldots x\}; x \in N$, in matrix format, M represents for products and x represents for the production pyramid level, the product pyramid has many stages, each stage has its own output vector, each output vector represents for the quantity and the combination of goods and services. Onwards, we define the input cost per unit as $C_i = \begin{bmatrix} c_1 \\ \ldots \\ c_2 \end{bmatrix} \in R^{N_i}, i \in \{0 \ldots x\}; x \in N, N_i = M_{i-1}$, $(c_1 \ldots c_n)_i$ stands for the total cost of the subject, for instance, the interest, whereas rents, taxes are ruled out. The physical transformation rate could be described as:

$$F_i = \begin{pmatrix} f_{1,1} & \cdots & f_{1,M_{i-1}} \\ \cdots & \cdots & \cdots \\ f_{1,M_i} & \cdots & f_{M_{i,}M_{i-1}} \end{pmatrix}_i \in R^{M_i \times M_{i-1}} \tag{4}$$

In formula $f_{M_{i,}M_{i-1}}$ is the quantity of M_{i-1} he input consumed by the $M_{i,}$ th unit output during production process, each column stands for the quantity of specific input consumed by producing unit output, each row stands for an input volume vector consisting of M_{i-1} inputs for unit of one specific output. The inputs here could be capital, labor, energy or whatever.

Without rents (positive or negative), taxes and subsidies, for $i \in \{0..x\}$ level of the production pyramid it holds that:

$$C_i = F_i C_{i-1} \tag{5}$$

If the I/O quantities are taken into account:

$$Q_{i-1} = Q_i F_i \tag{6}$$

Therefore, cost vector per unit of output C_x and the input quantity vector:

$$Q_0 \in R^{M_0} \tag{7}$$

$$C_x = \left(\prod\nolimits_{i=x}^{1} F_i\right) C_0 \tag{8}$$

The transformation of input from i = 0 to i = x is described as (9) below:

$$\prod\nolimits_{i=x}^{1} F_i = F_x F_{x-1} .. F_2 F_1 \tag{9}$$

Product φ_i here means the sum up of corresponding costs, it is described in monetary terms:

$$\varphi_i = Q_i F_i C_i \tag{10}$$

Afterwards, the total costs of level x could be derived as:

$$\varphi_x = Q_x \left(\sum\nolimits_{i=x}^{1} F_i\right) C_0 \tag{11}$$

Given $e = [1 \ldots 1]$ and T stands for transportation, thus we could sum up the output quantity as qi:

$$q_i = Q_i e^T \tag{12}$$

Through adjusting (12) and (7), we could get the ratio of output quantity to input quantity:

$$\frac{q_x}{q_0} = \left(Q_x e^T\right) / \left[Q_x \left(\prod_{i=x}^{1} F_i \right) e^T \right] \tag{13}$$

Equation (13) above is also the energy return on investment when energy input and energy output are both included and calculated.

5 The Link Between I/O Price Ratio and EROI

The link between input and output price ratio and EROI is complicated.

γ_x represents for the cost-based price per unit of output:

$$\gamma_x = \varphi_x / (Q_x e^T) \tag{14}$$

According to (14) above, taxes and rents are not contained in the costs φ_x, Q_x stands for the practical final output, Thus, all of the inputs could be described by φ_x. Therefore, the average unit cost of the primary inputs γ_0 is:

$$\gamma_0 = \varphi_x / \left[Q_x \left(\prod_{i=x}^{1} F_i \right) e^T \right] \tag{15}$$

Since the energy I/O have the same units, thus, the energy cost ratio could be denoted as:

$$ECR = \frac{\gamma_x}{\gamma_0} = \left[Q_x \left(\prod_{i=x}^{1} F_i \right) e^T \right] / (Q_0 e^T) \tag{16}$$

According to (16), the right side of (16) is reciprocal to that of (13), therefore

$$EROI = 1/ECR \tag{17}$$

In the completely competitive market, the total costs stand for the price [20]. However, in practice, since complete competitive market calls for the same curve for all of the producers, thus energy markets are usually incompletely competitive. What's more, the transportation cost of some kinds of energy are very expensive, for instance, oil and natural gas, which makes the market become incompletely competitive. At times, the markets are influenced by some intangible factors, such as political relationships, cartels and price agreements. In practice, Rents, taxes and subsidies could not be ignored in the price composition of one product.

Considering rents, taxes and subsidies, we could express price P_i as:

$$P_i = C_i + R_i + G_i = \begin{bmatrix} c_1 \\ \ldots \\ c_N \end{bmatrix}_i + \begin{bmatrix} r_1 \\ \ldots \\ r_N \end{bmatrix}_i + \begin{bmatrix} g_1 \\ \ldots \\ g_N \end{bmatrix}_i \tag{18}$$

C_i represents for the costs R_i represents for rents and G_i represents for governmental interventions. The downstream input costs are established on the basis of upstream output price, therefore:

$$C_i = F_{i-1}P_{i-1} = F_{i-1}(C_{i-1} + R_{i-1} + G_{i-1}) \tag{19}$$

Other than the cost φ_i, (11) describes that the subsidies, taxes and rental are included in product y_i:

$$y_x = Q_x\left\{R_x + G_x + F_{x-1}\left\langle \begin{array}{r} R_{x-1} + G_{x-1} + F_{x-2}\ldots \\ R_1 + G_1 + F_0(R_0 + G_0 + C_0) \end{array}\right\rangle\right\} \tag{20}$$

Equation (20) could be divided into two parts: the aggregate rental plus taxes minus subsidies $y_i - \varphi_i = \rho_i$ and input cost φ_i. Therefore,

$$P_x = y_x/\left(Q_x e^T\right) \tag{21}$$

$$P_0 = y_x/\left[Q_x\left(\sum_{i=x}^{1} F_i\right)e^T\right] \tag{22}$$

P_x is the unit price of input and P_0 represents the unit price of output, which are constituted by taxes, rental, minus subsidies ρ_x(resp. ρ_0) and unit cost γ_x.

$$\rho_x = (y_x - \varphi_x)/(Q_x e^T) \tag{23}$$

$$\rho_0 = (y_x - \varphi_x)/[Q_x(\sum_{i=x}^{1} F_i)e^T] \tag{24}$$

It's difficult to get the cost data than price and rent data. Therefore, (25) is more feasible than (17):

$$EROI = (P_0 - \rho_0)/(P_x - \rho_x) \tag{25}$$

At times, some variables are not easily accessible, we can only get price data, therefore, and one could compute energy price ratio of (22) into (21):

$$EPR = \frac{P_x}{P_0} = [\frac{Q_x\left(\sum_{i=x-1}^{0} F_i)e^T\right]}{Q_0 e^T}) \tag{26}$$

Given the share of rental, taxes and subsidies among EPR and EROI is the same, thus ERP equals ECR:

$$\frac{1}{EPR} = EROI\ \rho_x/P_x = \rho_0/P_0 \tag{27}$$

Equation (27) is able to explain the relationship between oil price and energy return on investment. When defining levels 0 and x, scholars can make slight adjustment according to specific situation. In practice, x could be substituted by i;$i \in \{0 \ldots x\}$; $i \in N$ while level 0 could be substituted by $i - n$; $n \in \{0 \ldots i\}$; $n \in N$ from Eqs. (7) to (27). Thus, the model is able to obtain the energy efficiency of intermediate output production at any stage of the production pyramid.

In CERM model, matrices F_i, which denotes the consumption of the input per unit of output, is substituted by matrice*s* B_i; $i \in \{0 \ldots x\}$; $x \in N$, which denotes the quantity of the output per unit of the input. Thus, (5)–(8) and (11) could be written as:

$$C_{i-1} = B_i C_i \tag{28}$$

$$Q_i = Q_{i-1} B_i \tag{29}$$

$$C_0 = \left(\prod\nolimits_{i=1}^{x} B_i\right) C_x \tag{30}$$

$$Q_x = Q_0 \left(\prod\nolimits_{i=1}^{x} B_i\right) \tag{31}$$

$$\varphi_x = Q_0 C_0 \tag{32}$$

Through using the equations above, we could obtain the rest of the results. However, the output (32) could not be decomposed. Equation (31) tends to lead the scholar to use available sources Q_0 to project the production of output Q_x, irrespective of the needs. In contrast, if the input in (8) is inefficient, it allows the user to make adjustment during the production process (adjustment of I/O matrices $F_0 \ldots F_x$). Theoretically, (8) and (32) is the same. Whereas, in reality, (27), (28), (29) and (30), which represents the full costing, are usually neglected by scholars for supporting the retrograde costing to the advantage of consumer.

In this paper, we utilize (8) to include some outputs into inputs through making adjustments on I/O tables. This is why we describe the input quantity as the function of the output quantity. Besides, input costs are usually not the function of output cost-based price.

CERM has a very important assumption: all of the factors in production process could be expressed in the form of energy [1, 9]. Land is made of vegetables, animals and raw materials, etc. But at the same time, it's the human activities, physical cost and energy which exploit these factors. Thus, the following part showcase the links between physical cost, energy and labor.

6 Output and Energy

Close dependent relationship exists between energy consumption and GDP [21]. We have obtained the GDP and energy consumption data of 33 EU countries from EUROSTAT during 1990 to 2014. In this paper, to offset the policy impact, we will utilize the orthogonal least squares algorithm to find out the relationship between energy consumption and the product.

Table 1 describes the OLS regression results of the GDP in 2015 constant EUR to the energy consumption. As shown in Table 1, the regression coefficient shows an

Table 1 Simple OLS regression of the GDP

Year	Complete records	Constant (mio EUR)	Regression coefficient	Adj. R^2
1995	16	−41,327	0.143	0.932
1996	17	−21,263	0.137	0.961
1997	18	−30,415	0.140	0.964
1998	20	−40,146	0.141	0.965
1999	20	−44,971	0.145	0.966
2000	30	−47,642	0.142	0.944
2001	30	−43,127	0.140	0.946
2002	31	−44,863	0.144	0.949
2003	31	−44,982	0.147	0.955
2004	31	−45,254	0.152	0.962
2005	32	−44,133	0.156	0.966
2006	33	−44,915	0.155	0.965
2007	33	−47,248	0.158	0.962
2008	33	−50,826	0.159	0.964
2009	33	−46,783	0.161	0.961
2010	33	−48,317	0.162	0.962
2011	33	−49,013	0.165	0.959
2012	33	−56,324	0.177	0.956
2013	33	−55,719	0.177	0.956
2014	33	−52,376	0.179	0.955
2015	33	−54,946	0.176	0.956
2016	32	−54,992	0.187	0.959
2017	32	−51,997	0.189	0.965
2018	32	−48,416	0.192	0.970

upward trend, rising from 0.143 in 1995 to 0.192 in 2018, the constant column shows the economic dependence on energy, which has been explained in sections above. The negative figure shown in Table 1 means that the GDP is heavily rely on energy consumption, and the situation could be gradually deteriorating if the government and market do not take measures to increase energy efficiency, more wealth creation means excessive unreasonable energy consumption due to intangible factors. Without energy, nothing would be created and previous achievements would be exploited without replacement, which is in according with contemporary EU population and fictional state of no energy available, except for the solar energy.

Eventually, the model gives us a clear view on the relationship between economic growth and energy consumption. From Table 1, we could see that the main factor causing the GDP variation is the variation of energy consumption, it accounts for at least 93.2% of GDP variation during the period of 1995 to 2018. According to the results, most R2 are concentrate within the range from 0.93 to 0.97. Therefore, the variation of energy consumption accounts for 93 to 97% of product variation. This conclusion supports the assumption in this paper: Nowadays, energy is the fundamental production factor in developed countries. However, EUROSTAT makes no provision for data of profits share in GDP, which make it impossible for us to identify if the rest 3–7% of the puzzle are rental or intangible factors.

6.1 Labor and Energy

Ancient basic inputs, such as crops, horses and trees are heavily relying on solar energy. However, things have been changing all the time, nowadays, the price of these inputs are mainly depended on the price of energy and labor. What's more, labor cost is primarily depended on energy price, which was especially obvious compared with the oil price and electricity price (shown as Fig. 2). Figure 2 describes annual percent change of seasonally adjusted average hourly earnings of production and nonsupervisory employees in the private sector. It also describes annual percent change of electricity consumer price index.

The data are selected from St. Louis in U.S. from 1968 to 2018 because of its availability and it has enough time series for study. Figure 2 shows the correlation between wages and electricity prices. Through calculations, the correlation coefficient between wages and electricity is 0.72, despite the orthogonal least squares' coefficient of electric prices to wages is merely 0.37. Besides, using the model with constant, the cointegration regression of the two variables is $R^2 = 0.49$, and respectively $R^2 = 0.73$.

According to Fig. 2, not only the electric prices but also the hourly earnings saw a steadily increase in a very long period of time, the electricity CPI rises to 6.87 times of the 1967 level, hourly earnings rises to 7.27 times of the 1967 level.

For comparison, we have collected data of some OECD countries from 1995 to 2018, the results show similar picture (Shown as Fig. 3).

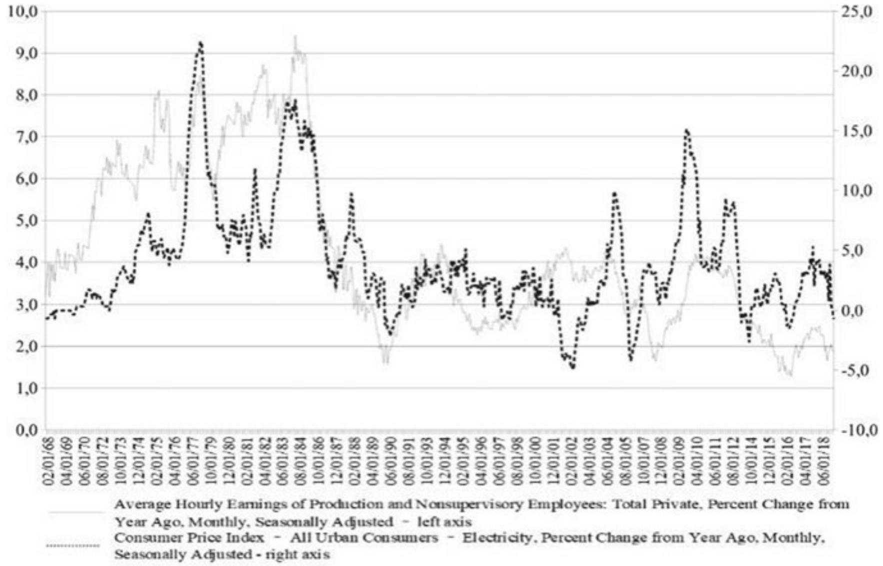

Fig. 2 Percent changes of average hourly earnings of production and nonsupervisory employees in the U.S. and electricity CPI; *data source* Federal Reserve Bank of St. Louis, own calculations

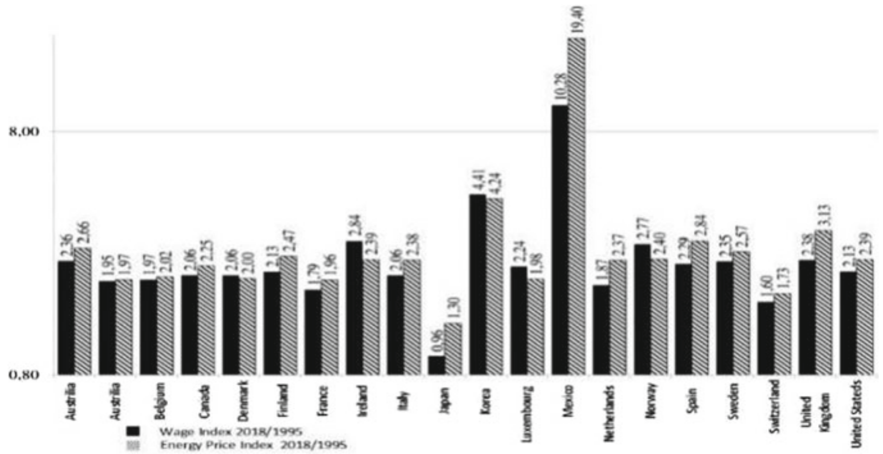

Fig. 3 Basic index of consumer energy prices and wages during 1995–2018 period in OECD countries; *data source* OECD, own calculations

According to Fig. 3, we could see wages growth has close relationship with energy consumer price index from 1995 to 2018. We could get a regression equation between the wage index 2018/1995 (y) and the energy CPI (x) with Mexico dummy:

$$y = -0,07238 + 0.87137 \times x - 8,37423 \times Mexico$$

$$R^2 = 0.943 \tag{33}$$

Therefore, labor price percent changes could reflect energy price percent changes in virtually 1:1 ratio in OECD countries. Through analyzing the U.S. and OECD data, we could draw a conclusion that:

$$Labor\ price \approx constant \times energy\ price \tag{34}$$

For the long run, we could use any type of price P_i of the production pyramid. Some scholars might hold skeptical view on this matter, believing that the labor price could only be replaced at the aggregate level. However, modern production is an extreme complicated process, which contains all sorts of energy and labor factors [22–24], in this paper, we assume (28) could be utilized in most of energy price evaluation situations for the long run. Whereas, the variation of rental and subsidies could lead to great fluctuation of energy price and the change could be much larger than wage fluctuations.

What's more, we could draw two possible explanations for the regression results. First is the cost of energy determines the cost of labor and energy is the main input for labor. Second is energy and labor are two factors which are close substitutes in production process.

These two conclusions make it possible for us to replace labor for energy, or let us make energy as the main input for labor in $F_x \dots F_0$ production matrices.

6.2 Physical Capital

The utilization of energy and labor constitutes physical capital, thus, if we could simulate the relationship between energy price and labor price, then it is easy for us to express the physical capital in the form of energy prices. According to the analysis in the section above, the relationship between energy prices and physical capital only exists in the long run or in the case of slight changes of rental, taxes and subsidies.

Product could also be used as an important factor for us to figure out the relationship with energy prices and physical capital. Labor, land and capital are three fundamental elements production factors. The cost of land could not express directly, but it could be indirectly expressed by the labor and physical cost consumed in obtaining fruits grown from land. Therefore, product is greatly influenced by the energy consumption while labor and costs also influence energy price. What's more, physical capital price is heavily rely on energy price and its creation on energy consumption. Based on the analysis above, it is clear that energy is the fundamental input factor which constitutes physical capital creation and this could be served as the assumption of CERM.

7 Discussion

In the sections above, we try to figure out the relationship between energy efficiency and energy price through mathematical modeling, we have found three reasons which make CERM different from energy I/O models:

Firstly, traditional energy input and output models are usually based on sectorial transaction matrices [25]. Whereas CERM uses the main input factors to express production, which makes accounting available for circularities, containing the consumption of final report.

Secondly, traditional input and output models usually divide output into two separate types: the intermediate output consumed by the industry and the real ultimate output. In reality, we found that this division unnecessary for discovering the relationship between energy efficiency and energy prices. On the contrary, it makes the analysis much more complicated, which is actually pointless [8].

Thirdly, the goal of building energy input and output models are to simulate energy flows in input and output matrices. The advantage of the I/O model proposed here is that it has no units' restrictions on input and output matrices for energy or money. However, we need to use energy to express inputs and outputs to obtain energy efficiency results, and energy inputs and outputs should be expressed in same units.

Other than the differences and advantages of CERM model, it also has some limitations. Firstly, as traditional models, the results also rely on the quality and availability of the input and output data. In other words, I/O prices are required for calculation. In reality, due to the extreme complexity of I/O composition structure, thus it is extremely difficult for us to figure out the exact structure of input and output. Since shares of labor and physical capital are easy to know, then the way round would be to assess that energy consumption structure for labor and physical capital.

Secondly, energy prices make another problem since they are highly influenced by rental, taxes and subsidies, which makes a great difference between the energy prices and the energy costs at times. This is not the case for input prices, we could easily get them since they are priced in the output. If the rental, taxes and subsidies are at the fundamental level of inputs, then it is possible for us to get reliable results from the ratio of I/O unit prices. Whereas, in reality, the I/O ECR are more applicable than the ratio of I/O energy unit prices in calculation process and we could take advantage of levelized cost of energy to speculate the energy unit cost ratio. However, since the energy return on investment (EROI) requires the comprehensive analysis of intangible energy consumption, thus we could still use the energy unit cost ratio to verify the accuracy of the results of energy return on investment despite the complexity of the calculation process [26, 27].

The energy price speculation by some studies discover that traditional energy prices are much cheaper than renewable biofuels. What's more, they found that photovoltaic and wind energy are more expensive compared with nuclear power and other fossil fuels. PV do provide as one energy source, however, the utilization and energy efficiency of photovoltaic is still pretty low in most areas [28]. It is also the case in terms of wave energy since current technology is not able to ensure the sustainability of solar or wave energy. Fortunately, with the improvement of technology and the consideration of externalities of various energy sources, the problem of sustainability of energy sources mentioned above could be improved.

At last, current energy policies fail to take the externalities during energy production process into consideration. How to increase the energy storage efficiency is another problem. Nowadays, the storage efficiency could reach to around 90% through using the most efficient way to store energy, for instance, dams or compressed air storage, except these storage methods, other methods like batteries could be too expensive. Other externality problems such as deforestation, pollutant emissions and soil compacting also need to be taken into account in producing biofuels, these problems could increase the exploitation cost of fossil fuels. Therefore, the additional cost of these externality problems requires further studies by scholars because these problems imply more energy consumption.

These problems tell us, in order to increase the computation accuracy, it is extremely important to take the intangible environmental and social factors into account when calculating energy efficiency. It is notable that some units of the environmental and the social I/O factors should be transformed into energy metrics, the input-output energy unit cost ratio could be an appropriate method in terms of units' transformation.

Empirical analysis of the CERM model need to be further studied by scholars, as it needs more literature review on methodology and input description.

8 Conclusions

Energy is of vital importance for the development of mankind, almost the development of every aspect in our society (technology, agriculture, and military) is based on energy consumption. Therefore, accurate evaluation of energy efficiency during the production process could help scholars to find out the way to allocate resources effectively and help governors to make appropriate energy policies. These reasons require scholars to study and find out the best method for energy efficiency evaluation. There are lots of energy efficiency evaluation methods currently, whereas these methods have shown different energy efficiency evaluation results, besides, the difference between I/O price ratios and energy efficiency ratios call for an improved energy efficiency evaluation model.

Since traditional energy efficiency methods make some limitations on system boundaries, therefore there is no available EE method now to take all of the energy demands into consideration during a complicated production process. What's more, capital and labor inputs are ignored by previous scholars when calculating energy efficiency, which leads to the underestimation of intangible input energy factors and causes the inaccurate results. Another problem which puzzles scholars is circularity. All of the problems above call for a better model to estimate EE accurately. The check for energy return on investment estimations' accuracy is conducted in this paper.

In this paper, production process is expressed through matrices without system boundaries, the result shows that the ratio of energy I/O unit costs is the same with EROI. What's more, it is also the case for I/O unit prices under the assumption that the shares of rental, subsidies and taxes of I/O price are the same. Since the huge differences in energy prices, ECR could be a much better substitution for energy price. It is notable that one need to figure out the energy inputs structure before using ECR or EPR.

This paper also analyzes and explain the expression of labor and physical capital, the conclusion shows that it is possible to express both of them in the form of energy. In the long run, labor price has strong links with energy price. Moreover, 94–97% of GDP changes for European countries could be explained by energy consumption. At last, further improvement of the model is needed for externality problems (social and environmental factors) and empirical analysis remains to be done by scholars.

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Optimization of Urban Electric Vehicle Rental Station Layout

Bowen Gao

Abstract In recent years, in some large cities, overburdened car ownership has brought serious congestion to urban roads Considering the influence of material interests of both electric car rental companies and customers and the location of the routing, Generally, the solution to the bi-level programming model is to solve the lower-level programming by a given upper-level programming variable, find the concrete form of the response function, and then substitute it back into the upper layer. Of course, this is more difficult. In this paper, a heuristic algorithm is proposed to solve this problem by the special form in the lower model a bi-level programming model to describe the city electric car rental point layout optimization problem, and solve the model. Finally, a numerical example is given to validate the model. The results show that the method is effective and feasible.

Keywords Electric car · Timeshare rental · Bi-level programming model · Heuristic algorithm

1 Introduction

With the outbreak of the second industrial revolution, the world automobile develops rapidly. The popularity of cars began in the United States, followed by Europe and Asia. In just 40 years, from 1950 to 1990, world car production increased 3.5 times, from 8 million to 36 million. Car ownership increased eight times, from 50 million to 440 million. In 2007, there were nearly 920 million cars in the world. Due to the continuous rise of China's economic, the number of private cars increased year by year. In 2012, China's private car ownership reached 93.09 million with an annual growth rate of 18%. In recent years, in some large cities, overburdened car ownership has brought serious congestion to urban roads. In 1991, the average speed of motor vehicles in the city center was 15 km/h during the rush hour in Shanghai, and urban

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Table 1 Contribution rate of different pollution sources to atmosphric pollution in Tokyo

Source of pollution	Carbon monoxide	Nitrogen oxides	Nitrogen hydride	Sulfur dioxide
Factory	0.1	64.0	2.0	99.0
Airplane	0.2	0	0	0
Car	99.7	36.0	98.0	1.0
Total	100	100	100	100

residents wasted 240H in traffic jam on average in their lives. The traffic jams are indirect waste of energy, and the emission of automobile exhaust, which is the main source of air pollution like carbon monoxide, nitrogen oxides, hydrocarbons, sulfur dioxide, also seriously affects our environment. For example, contribution rate of different pollution sources to atmospheric pollution in Tokyo shown in Table 1 [1].

So, in June 2012 the state council promulgated the energy saving and the industry development plan of new energy vehicles (2012–2020) [2]. In the plan, the electric car was first defined as the key point of the technical route among new energy vehicles. However, the production cost of the electric car is far higher than the average fuel cars. The electric car battery technology is not matured and infrastructure supply like charging posts in domestic has not been popular [3]. A multi-objective decision model for optimal planning of charging station is established by using Monte Carlo simulation method, and then transformed multi-objective optimization problem into a single-objective optimization problem by using analytic hierarchy process. Finally, an improved binary particle swarm optimization algorithm is used to determine the candidate site and capacity of the charging station [4]. Before breakthrough of the battery technology or complete of the infrastructure, people will not choose and buy electric cars. Thus, the appropriate business model can be a good promotion on electric cars.

Electric timeshare rental refers to an emerging business model in which an electric car is assigned to different users in the different time. This model is less complex than traditional car rental on hire formalities and more convenience than the net rental. The electric car rental is more high-profile because of the environmental protection effect and the stimulus of new energy industry policy. Because the timeshare rental pattern of electric car just starts, it has significant social significance to study the layout of rental station (Fig. 1).

An and Gao said a site selection model was established by minimizing the distance from the user to the electric facilities and minimizing the duration of the electric cars in the rental station [5, 6]. In the model, the influence factor of electric car rental location was analyzed and the public service facilities principles are satisfied. Xian said the layout of electric car rental station is illuminated considering the scale, the density and the micro location of lease station [7]. Correia and Antunes said the profits of car sharing organization are discussed by taking account of all revenues and expenses according to mixed integer programming model [8]. Cepolina and Farina said the scale of electric car rental system and car dispatch among different rental station is studied [9].

Fig. 1 Urban electric vehicle

The optimization of urban electric car rental station layout in its essence is a kind of selection problem about facility location, which is a collection of many optimization problems. According to the current study, the solution of the problem can be divided into three models: continuous model, discrete model and the grid model [10–13].

In Fig. 2, a given an area has a number of traffic plot. The problem of electric car rental station selection is to identify the position of lease station and community needs in the area by coordinating and optimizing lease demands. As shown in Fig. 3, the black triangle indicates demanding position while the black dot points to optional lease station.

Fig. 2 Rental station

Fig. 3 The schematic diagram of urban electric car rental station layout plan

How to determine the layout of the electric car rental station, make the electric car rental revenue maximization, reduce the total travel cost and rental station construction cost is the problem of this paper.

2 Model Establishment

2.1 Method of Model Establishment

Electric car rental point layout optimization issues, need to consider two aspects: first, leasing companies and relevant departments need to put forward a reasonable layout program makes the entire system travel costs and construction costs the lowest; second, they need their own travel costs the lowest. We can think of the leasing company as the decision maker in the whole planning, and the decision maker changes the choice of the traveler by changing the size or location of the lease point, but cannot control their choice. Travelers according to their own needs and travel habits to choose electric car rental point. A double layer model l has been used in this paper, as the problem contains two aspects.

2.2 Upper Model Construction

The upper model can be described as a decision-making department that can meet the minimum cost of the traveler's travel demand. The costs described here include the cost of electric vehicles, charging piles and leasing point construction costs.

The upper layer planning model can be described as:

$$min\ F = \sum\nolimits_{j=1}^{m} \left(c_1 X_j + c_2 Y_j + c_3 S_j\right)\zeta_j \tag{1}$$

$$s.t. \quad \sum\nolimits_{j=1}^{m} a_{ij}\zeta \geq 1 \tag{2}$$

$$Y_j \geq \sum\nolimits_{j=1}^{m} D_{ij} \tag{3}$$

$$X_j \geq \sum\nolimits_{i=1}^{m} O_{ij} \tag{4}$$

$$\zeta \in \{0, 1\} \tag{5}$$

where: n: the number of points required; m: the number of alternative leases; c_1: the price of electric vehicles; c_2: the price of the charging pile; c_3—the average cost per square meter of the site; X_j: the number of electric vehicles at the leasing point j; Y_j: the number of charging piles at the leasing point j; a_{ij}: 0–1 variable, if $t_{ij} \leq t_{max}$, which means that the demand point *i* is covered by the lease point j, $a_{ij} = 1$; otherwise $a_{ij} = 0$. t_{ij} represents the non-motor vehicle travel time from demand point to rental point j, t_{max} means that the longest time people can tolerate for. ζ_j: 0–1 variable, 1 means that construction lease has been built at point j, otherwise 0.

The upper model objective function is from the perspective of the electric car rental company, the goal is to make its early construction costs the lowest. (2) ensure that each demand point is covered by at least one alternative lease point; the (3) indicates that the number of charged piles at point *j* is not less than the total number of vehicles at point *j*; the (4) indicates that the number of electric cars should be less than the total number of cars can be rented; (5) is constants of variable 0–1. In the upper model, the number of rented vehicles O_{ij} and the number of returned vehicles D_{ij} are obtained by the lower level model.

2.3 Lower Model Construction

Travelers who travel at various points of demand will estimate the travel expenses for the leasing point. They will choose the lowest cost and the most efficient leasing point at last. The following utility function can be used to describe travel behavior [14]:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{6}$$

where,

U_{ij}: the lease point j on the demand point i: traveler random utility value;V_{ij}: the lease point on the demand point i traveler fixed utility value; ε_{ij}: random error.

We see the Logit model as a random utility model, For the lease point *j,* the probability of being selected of the demand point i is p_{ij}. It is assumed that the random error ε_{ij} in the utility function is independent of each other and follows the gamble distribution, then we can get:

$$p_{ij} = \frac{e^{\theta V_{ij}}}{\sum_{g=1}^{m} e^{\theta V_{ig}}} \tag{7}$$

$$r_{ij} = (O_i + D_i)p_{ij} = (O_i + D_i)\frac{e^{\theta V_{ij}}}{\sum_{g=1}^{m} e^{\theta V_{ig}}} \tag{8}$$

where O_i and D_i are the total number of rental cars of demand point i.

The lower model is [15, 16]: $r_{ij} \leq Ma_{ij}\zeta_j$

$$min\, Z = \sum_{i=1}^{m} \sum_{j=1}^{m} \int_0^{r_{ij}} f_{ij}(x)dx \tag{9}$$

$$s.t. \qquad \sum_{j=1}^{m} r_{ij} = O_i + D_i \tag{10}$$

$$r_{ij} \leq Ma_{ij}\zeta_j \tag{11}$$

where $f_{ij}(x)$ refers to the generalized cost function of the demand point i at the j th alternative lease point. This function increases as the demand increases, and can be described as: $f_{ij}(x) = \frac{1}{\theta} ln\, x - V_{ij}$. M is a sufficiently large positive number. Equation (10) indicates that all requirements can be met. Equation (11) can ensure that the traveler can only return a car in the existed vehicle rental points.

3 Model Solving

Bi-level programming model belongs to the NP-hard problem, which is difficult to solve. Ben-Ayad, Boyce et al. have conducted an in-depth discussion on the double layer model, they argued that there is no polynomial solution for the NP-hard problem [17]. At the same time, because of the non-convexity of the double layer model, the difficulty of the solution is increased.

Generally, the solution to the bi-level programming model is to solve the lower-level programming by a given upper-level programming variable, find the concrete form of the response function, and then substitute it back into the upper layer. Of course, this is more difficult. In this paper, a heuristic algorithm is proposed to solve this problem by the special form of (11) in the lower model [18–20].

For (13), if $a_{ij} = 0$ or $\zeta_j = 0$, then $r_{ij} = 0$, the constraint can be removed. If $a_{ij} = 1$, $\zeta_j = 1$, then $r_{ij} \leq M$ is an arbitrary number that can be removed by satisfying the constraint. For a fixed a_{ij} or ζ_j, the constraint conditions in the lower level model can be omitted. The (11) can be transformed into the following form:

$$r_{ij} = Ma_{ij}\zeta_j - y_{ij} \tag{12}$$

In (12), y_{ij} represents the relaxation variable, when $a_{ij} = 0$ or $\zeta_j = 0$, the values of r_{ij} and y_{ij} can be obtained directly. When $a_{ij} = 1$, $\zeta_j = 1$, the existing method can be used to solve the lower level model, and calculate the equilibrium state of the r_{ij}^*. The (12) can be used to calculate the value of the slack variable y_{ij}^*. The relationship of all response functions can be described as.

We will be substituting (13) into the upper objective function to solve it. Using the optimal solution to solve the lower problem, you can achieve the user's satisfaction. We can get a new location scheme by repeating this idea, and finally hope to converge to the optimal solution of the two-layer model. The calculation steps are as follows:

$$r_{ij} = Ma_{ij}\zeta_j - y_{ij}^* \tag{13}$$

Step 1: Set an initial feasible solution ζ_j^0, and the iteration step $k = 0$ at this time;
Step 2: For a given solution ζ_j^k for the upper model, solve the lower model and get r_{ij}^k;
Step 3: According to (13), y_{ij}^k is calculated and the relation $r_{ij} = Ma_{ij}\zeta_j - y_{ij}^k$ is substituted into the upper objective function. The upper problem is solved by branch and bound method, and a new set of solutions ζ_j^{k+1} is obtained;
Step 4: If $\left|Z^{k+1} - Z^k\right| \leq \varepsilon$, stop iteration, otherwise let $k = k + 1$, turn to Step 2. ε is iterative precision.

4 Analysis of Examples

We give an example to verify the two-layer model in the optimization of urban electric car rental station layout. The numerical values in the example are assumed. In practice, data acquisition requires observations of the field.

In Fig. 4, its central area ④ is the city's CBD and the area ①, ②, ③ are three traffic areas. The problem of the urban electric car rental station layout is to optimizing demand locations and identify the position of lease station and community needs. As shown in Fig. 3, the black box indicates demanding position while the red dot points to optional lease station.

According to the distance between the demand locations and the lease stations, the relationship between each demand location and the lease stations are shown in Table 2:

Table 2 The relationship between each demand location and the lease stations

Demand location	Alternative lease station
1	1
2	1
3	2.3
4	2
5	4
6	5

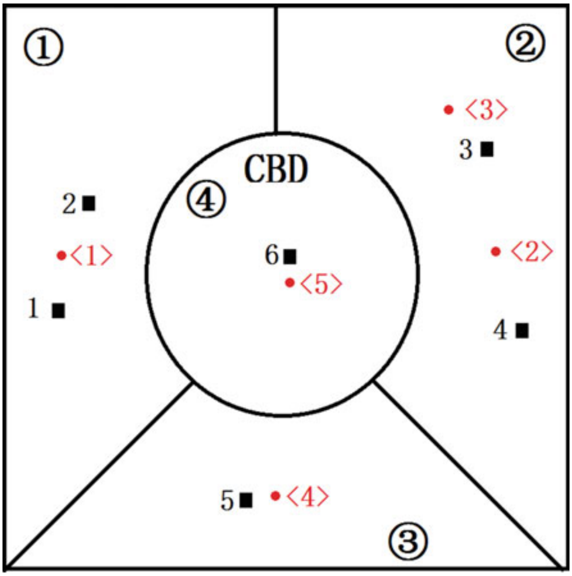

Fig. 4 The schematic diagram of traffic area division and alternative locations

As shown in Table 2, we have

$$a_{ij} = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

According to the algorithm steps:

Step 1: Initialization. Supposing that all the optional locations are to build lease stations, variable $\zeta = (1, 1, 1, 1, 1)$ and $k = 0$.
Step 2: Solving the lower model. Get the r_{ij} distribution under the equilibrium condition and obtain the relationships between the reaction functions.

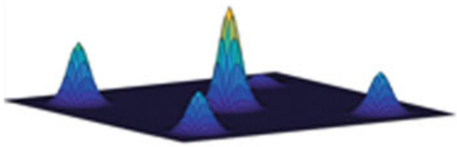

Fig. 5 The result of MATLAB simulation

Step 3: Getting the corresponding linear relationships according to the corresponding conditions and plug into the upper level model.
Step 4: Using the branch and bound to calculate a new site selection plan $\zeta = (1, 1, 1, 1, 1)$.
Step 5: Verifying the convergence.

Finally, we used MATLAB software for the simulation. The result is shown in Fig. 5.

According to Fig. 5, we can find that compared with other alternative locations, the numbers of user who select the optional location 4 is far less than other locations and the highest amount of choice is the CBD area, which is consistent with the actual.

5 Conclusions

The author expresses the optimization of the layout of urban electric vehicle rental points with the two-layer planning, and fully considers the interests of rental companies and users. The rental companies and relevant departments need to minimize the travel cost and construction cost of the whole system through a reasonable layout plan. For the driver, they need their travel cost is the least, which is more in line with the actual situation. Finally, a simple example is used to solve the model, and MATLAB software is used for verification. The experimental results show that the model and algorithm proposed by the author are feasible and effective and are significative to the production practice. Tn reality, the lease points, including the human cost, social cost, population density, the university area, jobs, retail and entertainment district, tourist attractions, transport hub and transit stations, need actual monitoring data acquisition, and are much more complex compared with the numerical example. Because of the dynamic nature and uncertainty of each data and other factors, it is necessary to use more effective algorithm to solve the model, which is also the author's next in-depth research direction.

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The Effect of Sci-Tech Finance Investment on Innovation of TMT Industry: An Empirical Research Based Panel Date Model

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Abstract Innovation is the key to the development of Chinese New Economy, and the improvement of innovation ability needs strong financial support. TMT industry, an important part of China's strategic emerging industries, has contributed the largest technological advancement in the past few decades with the help of government. Based on this, this paper selects panel data of 100 listed companies in A-share TMT industry from 2013 to 2017 as samples to empirically test the impact of sci-tech finance investment on the improvement of innovation level. The main conclusions are as follows: Firstly, enterprises' innovation investment and venture capital have a significant positive effect on innovation of TMT industry, while government financial expenditure on science and technology and commercial bank credit have no significant impact on innovation of TMT industry, sometimes government support even shows restraint. Secondly, there are significant regional differences in the impact of sci-tech finance investment on innovation performance of TMT industry. At the end of this paper, some reasonable suggestions for the result are offered.

Keywords Sci-tech finance · Innovation · Regional differences · Panel data

1 Introduction

With the strong support from national policy, the scale of Chinese New Economy has approached 30 trillion yuan in 2017, accounting for more than 30% of GDP. Innovation is not only the key of developing the new economy, but also the way to implement the strategy of innovation-driven development in the current stage of China. As an important part of the new economic industry, TMT industry has made the greatest contribution to technological innovation in the past decades, played an important role in industrial restructuring and upgrading. It has been an important driving force for global economic growth in the past decades, and will also become a new engine leading China's economy in the future.

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The innovation of TMT industry can't be separated from the support of science and technology service system, in which the financial service system is a vital part. The financial service system constitutes the basic force of the science and technology service system by providing liquidity and research and development funds for new economic industry companies to promote their technological innovation.

In the context of the new economic era, it is of great significance to enhance the innovation ability of TMT industry through the support of sci-tech finance investment to accelerate industrial restructuring and upgrading. Based on this, this paper intends to make an empirical analysis of the impact of sci-tech finance investment on innovation of TMT industry, and provide reasonable suggestions for the integration of sci-tech finance investment and new economy in China.

2 Concepts and Literature Review

2.1 TMT Industry

TMT is the abbreviation of technology, media and telecom, appeared in the era background of continuous integration and development of communication, internet and information technology. The TMT industry, which is also called digital media industry, is a growing industry connecting the high-tech industry and communications industry based on the Internet. Specifically, it includes several areas: software and services industry, technical hardware and equipment industry, semiconductor products and equipment industry, telecommunications industry, consumer electronics industry, home appliances industry and media industry.

The TMT industry is a high return, high risk industry, with the characteristics of rapid development of industry size, market changes rapidly, product updates fast and high washing out rate. Because of these characteristics, TMT industry has become the capital favored target, especially venture capital. Even if the market environment fluctuates and the investment climate is not prosperous, venture capital institutions are still confident in the TMT industry, which has made the TMT industry always a battleground for capital competition. With the influx of large amounts of capital, the TMT industry will have a more positive future in a long time. Around the world, well-known companies in the industry includes some billion dollar companies, such Facebook, Google, Amazon and so on. In China, not only some giant industry companies such as Tencent, Alibaba, Baidu and Jingdong have emerged, but also some so-called unicorns such as ByteDance, Meituan, and Didi. These outstanding companies set a good example for other companies of TMT industry in China and point out the direction for future development.

As an important part of China's strategic emerging industries, it has contributed the largest technological advancement in the past few decades with the help of government.

2.2 Sci-Tech Finance

Sci-tech finance is the abbreviation of sci-tech finance. The so-called sci-tech finance is a financial system design for promoting technology innovation of high-tech enterprises. There are two traditional channels of sci-tech finance: one is government funds, which aimed to guide private capital into high-tech enterprises; the other are diversified equity financing channels for high-tech enterprises. Specifically, including the following: government support, technology loan and multi-hierarchy capital market and so on. Based on the existing research and the definition of sci-tech finance, this paper constructs the index system of sci-tech finance from four aspects: enterprise innovation investment, government innovation support, commercial bank credit and venture capital.

2.3 Relevant Literature

The science innovation needs the support of capital. The high risk and high return of scientific and technological innovation can fully exert finance's functions of spreading risk. In this way, the integration of technology and finance came into being, and sci-tech finance came into being. Some scholars believe that sci-tech finance provides financial support for scientific and technological innovation, thus improving enterprises' scientific and technological innovation ability; also has a scholar to think that the speculative nature of financial capital will lead to the emergence of staged mismatches in financial and technological innovation. Specifically, in the early stage of research and development, the financial capital input is small, while when the innovation indicates a promising future for modest profit, there will be a large influx of capital. From this point of view, sci-tech finance is not conducive to the improvement of science and technology innovation ability.

The research on the influence of finance on scientific and technological innovation started from economist Schumpeter. Schumpeter pointed out that financial variables play an important role in economic development and enterprise innovation. He believed that enterprise innovation is closely related to financial capital.

Foreign scholars did not put forward the concept of sci-tech finance, but they studied the relationship between financial capital and innovation from the macro and micro levels. Many foreign scholars have paid attention to the channels through which sci-tech finance acts on enterprises' innovation. For example, King and Levine used the endogenous growth model to make empirical analysis, tested the various channels through which finance promotes technical innovation of enterprise [1]. George and Prabhu argue that compared with commercial financial institutions, market-oriented financial markets represented by venture capital play a more significant role in promoting innovation. Sasidharan et al. constructed a model based on Euler equation, and through empirical analysis, found that the amount of R&D expenditure of enterprises was affected by their own profitability and external financing ability. There was a significant positive correlation between variables [2]. Po-Hsuan studied the panel data of several countries and compared the effects of stock financing and credit financing. The empirical results show that compared with endogenous financing, external financing can significantly improve the innovation ability of enterprises [3].

In China, the concept of Sci-tech finance was first put forward by Zhao, a domestic scholar. In his opinion, sci-tech finance is a system consisting of a series of financial instruments, institution, policies and services, aiming at promoting science and technology innovation. Its main participants include government, enterprises, markets and social financing institutions [4]. Lu and Han selected high-tech industries as samples and the empirical results show that sci-tech finance can effectively promote technological innovation, but there are regional differences, and there are different performances in different stages [5]. Zhang and Zhao based on China's provincial panel data, combined with dynamic and static analysis methods, verified the time effect of sci-tech finance on innovation: sci-tech finance can improve innovation performance in the short term, but there is no positive relationship in the long term [6]. Qian and Zhang selected A-share listed companies as samples to verify the positive relationship between sci-tech finance and enterprise R&D expenditure. They found that sci-tech finance provides support for enterprises' R&D investment by providing liquidity, effectively alleviating financing constraints [7]. Cao tried to construct an evaluation system of sci-tech finance. Taking Hubei Province as an example, he built a co-integration model to analyze the relationship between sci-tech finance and technological innovation. Empirical evidence also verified the role of sci-tech finance in lifting enterprise ability to innovate [8].

In summary, there are many meaningful studies on the impact of sci-tech finance investment on innovation by scholars at home and abroad, and the results are quite rich, but little attention has been paid to the research on TMT industry. TMT industry is the backbone of China's economic transformation and the leader of developing new economy and fostering new momentum. In the context of global competition for new economic development, it is of great significance to enhance the innovation level of TMT industry for the development of emerging industries and the realization of high-quality economic growth. Therefore, based on the A-share TMT industry, this paper selects panel data of 100 listed companies in A-share TMT industry from 2013 to 2017 as samples to empirically test the impact of sci-tech finance investment on the improvement of innovation level.

3 Theoretical Basis

Perez analyzed the relationship between financial capital and technological innovation from the perspective of technology and economic paradigm evolution. He studied the influence of financial capital on major scientific and technological innovation from four period of a company: start-up period, growth period, maturity period and recession period. He stressed that financial capital enters this field crazily to obtain huge profits during the growth and maturity stage of the technological revolution, while during the recession stage of the technological revolution, financial capital will withdraw from relevant fields and turn into idle capital to invest in other fields. Hongxing yin believe that knowledge innovation is the front end of scientific and technological innovation and the source of scientific and technological innovation. In this stage, the innovation achievements are basic and public, so the government investment should be the main part of the capital investment in this stage. However, in the later stage of scientific and technological innovation, that is, the stage of the industrialization of innovation achievements, due to the clear market orientation and investment interests, financial capital will generally actively intervene in this stage.

According to the theory of financial function, the science and technology finance can act on enterprise innovation activities through project screening mechanism, investment demand matching mechanism, information transfer mechanism, etc. A developed sci-tech finance system can better mobilize idle capital, increase the efficiency of matching between investment and demand, so as to provide full capital support for innovation projects. At the same time, the improvement of sci-tech finance can help investors to increase confidence in investment to create greater value for the enterprise with spreading risk effectively. Through more effective risk diversification mechanism, investors with low risk tolerance can participate in the financing of innovation projects. The influence of sci-tech finance on enterprise innovation activities has two sides, on the one hand, sci-tech finance provides financial support to strengthen enterprise innovation activities, improves the enterprise financing constraints, so as to promote enterprise innovation activities. On the other hand this financing constraint mitigation effect is inclusive, that means that when supporting individual businesses, competitors in the industry can also benefit from it. The result is an increase in market competition and a reduction in innovation revenues, which in turn inhibits corporate innovation activities.

The above theory illustrates the mechanism and path of science and technology finance to innovation.

4 Research Design

4.1 Selection of Technology and Finance Index

There are many studies on the evaluation index of sci-tech finance. Based on the existing research and the definition of sci-tech finance, this paper constructs the index system of sci-tech finance from four aspects: enterprise innovation investment, government innovation support, commercial bank credit and venture capital. The specific meanings of the indicators in this paper are as follows:

(1) *Enterprise's own innovation expenditure (R&D).* Choosing the research and development funds invested by TMT industry companies in innovation activities, this index describes the investment of TMT industry companies in innovation.

(2) *Government innovation support (Gov).* Selecting the proportion of science and technology expenditure in the local government's financial expenditure in the innovation activities reflects the intensity of financial investment in sci-tech finance, describes the government's investment in innovation of TMT industry company and its importance.
(3) *Commercial bank credit (Bank).* This paper describes the support of commercial banks for sci-tech innovation of TMT industry by using the ratio of loan quota of commercial banks to GDP of provinces where the company is located.
(4) *Venture capital (VC).* Using the annual total of venture capital in the company's location to describe the support of venture capital for sci-tech innovation in TMT industry.

4.2 Selection of Technology Innovation Index

The evaluation of enterprise innovation performance is always the hotspot of researches, as innovation is difficult to observe. Innovation is preceded by various factors, such as person, capital, technique, market information and so on. Therefore, it is difficult to directly quantify the innovation performance. Therefore, the existing research measures technological innovation by constructing alternative indicators. There are three common indicators for quantifying technological innovation: research and development investment intensity, patent application number and total factor productivity. However, due to the different focus of different studies, there are also some differences in the specific indicators selected by relevant studies.

The direct goal of innovation in enterprise is the commercial application of new technologies. Therefore, this paper uses revenue of core technological products (Rev) to measure technological innovation. The so-called revenue of core technological products refers to the income of enterprises through technological innovation. The rationality of this index is embodied in that the purpose of technological innovation of TMT industry enterprises is to obtain income through marketization, and it has better comparability.

4.3 Selection of Control Variables

Enterprise sci-tech innovation performance is affected not only by external financing channels such as sci-tech finance, but also by internal environment. In order to eliminate the interference of other factors on the results and eliminate the bias caused by multiple collinearity on the empirical results, this paper also chooses enterprise size and profitability as control variables. This paper chooses total assets to describe enterprise size (Size), and chooses return on net assets to describe profitability (ROE).

4.4 Model Building

To analyze the impact of sci-tech finance on technological innovation of TMT industry, the following econometric models are constructed based on previous research.

$$\mathrm{Rev} = \beta_0 + \beta_1 R\&\mathrm{D} + \beta_2 size + \beta_3 ROE + \varepsilon_t \tag{1}$$

$$\mathrm{Rev} = \beta_0 + \beta_1 Gov + \beta_2 size + \beta_3 ROE + \varepsilon_t \tag{2}$$

$$Rev = \beta_0 + \beta_1 Bank + \beta_2 size + \beta_3 ROE + \varepsilon_t \tag{3}$$

$$Rev = \beta_0 + \beta_1 VC + \beta_2 size + \beta_3 ROE + \varepsilon_t \tag{4}$$

$$Rev = \beta_0 + \beta_1 R\&\mathrm{D} + \beta_2 Gov + \beta_3 Bank + \beta_4 VC + \beta_5 size + \beta_6 ROE + \varepsilon_t \tag{5}$$

Among them, Rev stands for the technological innovation performance of TMT industry, R&D stands for technology innovation input of enterprises, Gov stands for technology innovation input of government, Bank stands for the loan of commercial banks in technological, VC stands for the venture capital support in technological innovation. In model 1–4, we explain the effect of sci-tech finance investment on innovation separately by each sci-tech finance index, while in model 5, we use four sci-tech finance indexes to explain the effect simultaneously.

4.5 Data sources and Descriptive Statistics

At present, there is no unified statistical data on TMT industry classification in China. This paper selects the data of TMT listed companies for empirical analysis. In terms of data selection, companies or enterprises providing products or services jointly constitute an industry, and industrial development is embodied in the development status of companies within the industry. The economic value and market performance achieved by the two should be logically consistent. However, the listed companies, as the representatives of the companies with relatively perfect management mechanism and stable business performance, the development status of listed companies can represent the growth of the industry to a large extent. Based on this, the data of TMT industry listed companies are selected to empirically investigate the effects of science and technology finance

In order to make the sample more representative, this paper chooses the sample companies of China's A-share TMT industry concept stocks as the empirical object.

Table 1 Variable description statistics

Variable	Mean value	Standard deviation	Maximum	Minimum
Rev	−3.604507	0.995984	9.568240	−0.478240
R&D	−8.002308	0.995984	8.394690	−0.946450
Gov	0.024985	0.035629	0.056783	0.008345
Bank	0.163325	0.042629	0.270069	0.080870
VC	−4.628907	0.995984	1.654110	−1.126720
Size	−1.837807	0.995984	9.333680	−0.428140
ROE	14.72352	15.74672	133.0600	−116.3400

Because of the serious lack of R&D input data before 2013, it chooses 2013–2017 as the time span. Finally, 100 companies from 19 provinces and municipalities enter the sample set. The company's core technology product income, enterprise innovation investment, commercial bank loans, total assets, return on net assets come from the wind consulting financial terminal. The balance of bank loans, government financial expenditure on science and technology, and regional GDP come from China Statistical Yearbook, and the amount of regional venture capital comes from China Equity Investment Market Annual Report issued by the Research Center of Qing Dynasty. If the original data is missing, the exponential smoothing method is used to make up for it. The descriptive statistics of the above data are shown in Table 1.

5 Empirical Analysis

5.1 General Empirical Analysis

Firstly, this paper uses fixed effect and random effect models to regress the above models. Fixed effect models are selected according to the test results, and the data are brought into model 1–5 to get the overall empirical results, as shown in Table 2.

According to the regression results in Table 2, the R&D, stands for enterprises' own innovation investment, are positive in both model 1 and model 5 with the 1% level of significance, which indicates that the impact of TMT enterprises' own innovation investment on innovation performance is significantly positive. For TMT industry companies, which are characterized by technological innovation and business model innovation, efficient and sustainable innovation is the magic weapon to form their core competitiveness and construct competition bulwark. Therefore, companies in the industry are always concerned about the direction of market development and the trend of technological innovation. Therefore, compared with the government and banks, companies in the industry can carry out innovative activities more targeted. Their innovative resources input can bring more effective innovative output, improve the overall innovation level of TMT industry, and drive the whole

Table 2 General empirical analysis

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
R&D	0.287*** (11.424)				0.281*** (11.158)
Gov		−0.480 (−0.561)			3.583* (1.609)
Bank			−1.545 (−1.445)		−1.083 (−1.210)
VC				0.210** (2.323)	0.186** (2.806)
Size	0.716*** (28.394)	0.802*** (29.358)	0.808*** (29.714)	0.810*** (29.630)	0.724*** (28.415)
ROE	0.001 (0.780)	0.001 (0.812)	0.001 (0.692)	0.001 (0.704)	0.001 (0.896)
R2	0.713	0.638	0.642	0.642	0.718

industry to continuously pursue cutting-edge technology and improve innovation efficiency.

In model 2, the coefficient of government innovation expenditure (Gov) is significantly negative and less significant, but in model 5, the coefficient of government innovation expenditure (Gov) is positive and significant at the statistical level of 10%. The results show that the impact of government innovation expenditure on innovation performance of TMT industry is weak. The reason may be that in terms of innovation, enterprises play a major role in promoting technological change, while the government and scientific research institutes only provide supporting services for industrialization. At the same time, many local governments are facing the same homogeneous predicament as enterprises in the competition. How to determine their participation degree in the development trend of industry, how to evaluate the innovation investment, and how to formulate corresponding industrial policies are all administrative risks faced by the government. Some local governments pay more attention to short-term benefits because of short-sighted tenure, but the return cycle of TMT industry technology innovation is longer, which results in insufficient government investment. On the other hand, some local governments invest too much in technological innovation in the industry, but the crowding-out effect of enterprises is greater than the promotion effect, thus inhibiting the improvement of innovation.

In model 3 and model 5, the coefficient of bank credit (Bank) is negative, contrary to expectation, but it is not statistically significant. It also shows that commercial banks have no significant effect on the innovation ability of companies belong to TMT industry. The reason is related to the “big enterprise bias” of domestic commercial banks in credit work. As most TMT industry companies are in the early stage of life cycle with short listing time and inadequate accumulation of assets, unable to obtain sufficient credit funds from commercial banks. Some scholars have studied the problem of insufficient financing of scientific research investment by banks for small and medium-sized technological enterprises. Xu argued that due to the high risk and long cycle of scientific research and development of small and medium-sized technological enterprises, the bank's credit supply for such enterprises is insufficient, and its support for technological innovation of them is limited.

In model 4 and 5, the coefficient of VC is positive and significant at 5%, which indicates the effect of venture capital on innovation performance of TMT industry is significant. Due to insufficient access to bank credit in TMT industry, TMT industry companies are more likely to resort to venture capital institutions for financing to carry out innovative researches. TMT has also been favored by venture capital. The investment in TMT industry accounts for an important proportion of the total private equity and venture capital investment. In 2017, the total investment is 141.951 billion US dollars, of which the investment in TMT reaches 72.762 billion US dollars, accounting for 51.2%, the half of the industry investment. A large influx of venture capital has injected energy into the development of TMT industry and contributed significantly to technological innovation.

From the perspective of control variables, the coefficients of Size in model 1 and model 5 are significantly positive. Enterprises' scale is the foundation to carry out the technical innovation, so it can pose a significant positive impact on innovation efficiency of TMT industry. The coefficient of return on net assets (ROE) is positive but not significant, indicating that the level of corporate profitability has no significant impact on technological innovation in TMT industry.

5.2 Region-Based Empirical Analysis

In China, regional economic development is uneven. TMT industry, as a representative industry of the new economy, has also shown different stages of development and characteristics in different regions. Therefore, this part divides the sample companies into three regions: east, middle and west, and explores the impact of sci-tech finance on regional TMT industry innovation. The empirical results are shown in Table 3.

According to the empirical results at the regional level, R&D is positive in the eastern and central regions and significant at the level of 5% or 1%, especially in the eastern region, which shows that the innovation performance of TMT industry in the eastern region is higher. The coefficient of western region is negative and significant. The reason may be that enterprises in the western region are limited by the level of regional economic development and lack sufficient funds for high-risk innovation activities.

The coefficient of government support (Gov) is positive in the East and west, but not significant. The coefficient of central region is negative, and passed the 10% significance level test. As mentioned above, there are insufficient or excessive government support for enterprise innovation, which leads to misallocation of resources and even inhibits the central region.

The results show that the impact of bank credit on innovation performance of TMT industry is limited nationwide. As mentioned above, there is a preference for

Table 3 Region-based empirical analysis

Variable	The east	The middle	The west
R&D	0.295*** (10.628)	0.082** (2.858)	−0.136** (−2.282)
Gov	2.983 (1.077)	−3.973* (−1.981)	15.31 (0.752)
Bank	−0.976 (−0.957)	−0.487 (−0.575)	−0.297 (−0.131)
VC	0.165* (2.677)	0.058* (1.987)	0.216 (1.161)
Size	0.721*** (26.402)	0.809*** (4.617)	1.102*** (9.550)
ROE	0.001 (0.674)	0.004** (2.068)	−0.002 (−0.842)
R^2	0.720	0.719	0.956

large enterprises in bank credit, and information asymmetry leads to a consistent trend in different regions.

In each model, the coefficient of venture capital (VC) is positive, but only the eastern and central regions pass the significance test, the western region is not significant, and the coefficient of the eastern region is significantly higher than that of the central region. This is related to the fact that China's venture capital organizations mainly gather in the eastern region, especially in Beijing and Shanghai. Meanwhile, the TMT industry in the eastern region is developing actively and has stronger innovation ability. It is easier to get the support of venture capital by integrating geographic and conditional advantages, which plays an important role in its own technological innovation.

6 Conclusions

TMT industry, an important part of the new economy, will become a new engine leading China's economy in the future. It is of vital significance for China to implement innovation-driven development strategy at the current stage by places a high importance on the role of sci-tech finance to help foster technological innovation of TMT industry. Based on the analysis of the key factors affecting the innovation capability of TMT companies in China, this paper selects panel data of 100 listed companies in A-share TMT industry from 2013 to 2017 to test the impact of sci-tech finance investment on the improvement of innovation. The main conclusions are as follows.

(1) *During the period of investigation, among the various financial indicators of science and technology, enterprises' own innovation investment and venture capital contributed significantly to the innovation performance of TMT industry,*

while government financial expenditure on science and technology and commercial bank credit did not play a significant role. At the same time, there are significant regional differences in the impact of sci-tech finance on innovation performance of TMT industry.

(2) *From the perspective of control variables, firm size has a significant impact on innovation performance of TMT industry, while asset profitability has no significant impact on innovation.*

The conclusion of this paper has important enlightenment significance for promoting the role of sci-tech finance in the new economic innovation represented by TMT industry.

(1) *Strengthen the guiding role of government financial funds and enhance the efficiency of government financial funds for innovation.* On the one hand, we should increase the proportion of scientific and technological expenditure in financial expenditure, and at the same time give full play to the guiding role of public funds in science and technology in industrial upgrading. We should also improve the mechanism of supervision and utilization of public funds in science and technology to prevent abuse of fiscal preferential policies.

(2) *Further improve the participation of commercial banks in the new economic industry.* Empirical results show that commercial banks still have "big enterprise bias" when granting credit, and give little support for TMT industry.
Therefore, they can specially create targeted financial products for TMT industry and further broaden financing channels for TMT industry.

(3) *Support the development of venture capital institutions of each region.* Venture capital is an important financing channel for TMT industry, which ensures the efficient implementation of innovative activities in TMT industry. We should actively support the development of regional venture capital institutions, and give appropriate policy support and tax preferences to venture capital funds invested in TMT industry.

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The Effects of Employee Stock Ownership in Chinese Listed Companies

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Abstract Employee stock ownership as an incentive method has an important impact on business performance and value. This paper uses the panel data of listed companies over the period 2015 to 2017 to test the impacts of employee stock ownership on corporate performance and corporate value. It is found that the implementation of employee stock ownership by listed companies can significantly improve corporate performance and corporate value. The high-tech enterprises and non-high-tech enterprises are grouped and tested as the standard. It is found that the effects of employee shareholding implementation are significantly different. The effects of high-tech enterprises in implementing employee stock ownership are better than that of non-high-tech enterprises.

Keywords Employee shareholding · Corporate performance · Corporate value

1 Introduction

In the past 30 years, China's employee stock ownership has undergone several policy adjustments due to the development of corporate-owned enterprises and the

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restructuring of state-owned enterprises. In June 2014, the China Securities Regulatory Commission issued the "Guiding Opinions on the Pilot Implementation of the Employee Shareholding Plan for Listed Companies". It marks that China's employee stock ownership plan has moved towards a new era of standardization, systemization and proceduralization. Under the background of mixed ownership reform and with the standardization of the employee stock ownership, it is very practical to study the effects of employee stock ownership in Chinese listed companies in that it is not only based on comprehensive and time-sensitive data, but also is beneficial to the development of China's employee stock ownership system.

In the analysis of the effects of employee stock ownership, domestic scholars' research mainly focuses on evaluating the effect of employee stock ownership from the perspective of wealth effect, namely, internal and external situations and corporate performance. It is believed that employee equity distribution enhances employee efficiency, and has a positive impact on corporate performance in the short term. Foreign scholars pay more attention to evaluating the effect of employee stock ownership from the perspective of incentive effect. Although domestic and foreign scholars have studied the implementation effect of employee stock ownership from different aspects, there is no unified conclusion that employee stock ownership has positive impacts on corporate performance and value. In addition, given China's special economic system and social environment, as well as the continuously improving policy system, Chinese employees have certain innovations in terms of models, systems and scales. Hence, it is necessary to further explore the effects of implementing employee stock ownership in China. Moreover, the data of previous studies on supporting conclusions are not comprehensive enough and lack time-sensitivity. Therefore, based on the previous research results, this paper mainly uses the method of multiple regression analysis to establish a regression equation model, empirically test the effects of employee stock ownership on incentive effect and wealth effect from the aspects of enterprise performance and enterprise value, and conduct group inspections research on high-tech companies and non-high-tech enterprises. The study found that the implementation of employee stock ownership by listed companies can significantly improve corporate performance and corporate value. In addition, the effects of employee stock ownership are different between high-tech enterprises and non-high-tech enterprises. The effects of the former are better than the latter.

The contributions of this paper are mainly reflected as follows: Firstly, this paper studies the effects of listed shareholding from the aspects of corporate performance and corporate value which supplements and improves the existing literature on the analysis of the effects of listed shareholding. Secondly, the previous studies rarely involved data after 2014, while this paper has taken advantage of the lasted data, which will help people have a better understanding of the effects of the employee stock ownership in Chinese listed companies.

The next section of this paper is the theoretical analysis and empirical hypotheses. Section 3 is the research design. Section 4 is the empirical analysis. Section 5 is robustness test. Section 6 is conclusion.

2 Theoretical Analysis and Research Hypotheses

Rosen believes that employee stock ownership has a positive effect on corporate performance [1]. Later scholar Ding agreed with Rosen's point of view [2]. Huang and Zhang also believe that the incentive effect of employee stock ownership on corporate performance is not blindly positive, and there may be an inflection point. Exceeding certain percentage, the company's performance began to decline or even have a negative impact [3]. Why is there a positive effect between employee stock ownership and corporate performance? This paper considers the reasons as follows: from the perspective of agency theory, employee stock ownership combines the long-term value of the company with the employees' own interests, and promotes the interests of employees and the interests of shareholders to be consistent. As an incentive mechanism, it can effectively improve operational efficiency and the company performance. From the perspective of two-factor theory, the development of industrialization has promoted the contribution of capital elements to production gradually surpassing the labor factors. Therefore, capital owners are increasingly in the position of superior distribution, and laborers can only rely on their own labor to obtain wage income. If employees are allowed to hold shares in the company, then this social injustice can be reversed. On the one hand, shareholding employees earn income through labor, and on the other hand, they can obtain dividends through capital, which can reduce the impact of excessive social wealth between the rich and the poor, and effectively improve corporate performance. In view of this, this paper proposes hypothesis 1:

H1: The implementation of employee stock ownership in listed companies has a positive impact on corporate performance.

Sharing economic theory believes that, in contrast to the fixed wage system, a profit-sharing wage system should be implemented so that ordinary workers can share the growth gains of enterprises by sharing profits, and it is possible to achieve price equilibrium under full employment conditions; asset specificity theory believes that as the owner of human capital property rights, employees should share with the shareholders the residual control and residual claims of the enterprise; the stakeholder theory advocates that employees as important stakeholders should also participate in corporate governance and share the residual interests of the enterprise. Therefore, this paper believes that employee stock ownership is regarded as an incentive system for reforming employee benefits. It can share the residual profits of enterprises, have residual control and claim rights, reduce agency costs, improve employee enthusiasm, increase company performance, and accumulate shareholder wealth and increase company value. This raises the hypothesis 2:

H2: The implementation of employee stock ownership in listed companies has a positive correlation with corporate value.

Although employee stock ownership can be used as an incentive to mobilize employee enthusiasm and promote the company's performance and value, large-scale employee holdings may also lead to "free-riding" behavior [4]. Or, because employees who are employed by management become shareholders will be too "friendly" to the management, they will reduce corporate performance and shareholder wealth [5, 6]. In summary, the impacts of employee stock ownership of listed companies on company performance and company value need further empirical testing.

3 Research Design

3.1 Concept Definition

The employee stock ownership researched in this paper is based on the definition of employee stock ownership in the "Guiding Opinions on the Pilot Implementation of the Employee Stock Ownership Plan for Listed Companies" issued by the China Securities Regulatory Commission in 2014, that is, the listed company makes legal measures according to the wishes of employees. The employee obtains the stock of the company and holds it for a long time, and the equity of the shares is allocated to the employees according to the contract.

3.2 Sample Selection

This paper selects the panel data of the listed companies in which the A shares of the Shanghai and Shenzhen Stock Exchanges are held from January 1, 2015 to December 31, 2017 as the overall sample, and takes the annual report data of listed companies for three years from 2015 to 2017 as the main object of analysis. The announcement date of the employee stock ownership plan is 2015, and the expiration date is 2017 or after 2017. Because the employee stock ownership plan has a time limit, the duration refers to the effective time of the employee's shareholding plan. Therefore, the implementation of employee stock ownership by the listed company during this period may have impacts on the company's performance and corporate value. Then, excluding the following samples: the financial insurance industry; ST company; samples of major events during the event window; companies that are unable to obtain complete data. Finally, a total of 591 observation samples were obtained, including 330 high-tech companies and 261 non-high-tech companies. The sample data in this paper are from iFinD and CSMAR database. Unattained data are manually obtained by looking through the company's annual report. To eliminate the effects of extreme values, the continuous variables involved were subjected to a 5% bound Winsorize process.

3.3 Variable Selection

(1) Employee shareholding variable. For the independent variables, most domestic scholars use the proportion of employee stocks in total share capital or the number of employees holding shares [3, 7]. In this paper, the ratio of employee shareholding to total share capital and the proportion of employees participating in the shareholding plan to the total number of employees are the employee shareholding variables.

(2) Corporate performance variables. Corporate performance refers to the company's business results in a certain period of time. There are many variables to measure the performance of the company, including return on assets (ROA), return on equity (ROE), operating profit margin, earnings per share (EPS), net profit growth rate, etc. In the literature on predecessors' research on the incentive effect of employee stock ownership, there are many performance appraisal indicators that select indicators related to net profit. After learning from the existing literature, this paper chooses ROE to measure the performance of the company (Table 1).

(3) Enterprise value variables. Stewart's book, The Search for Values, demonstrates the usefulness of EVA, arguing that EVA is closer to the real economic profit of firms than other financial measurement methods, better explaining corporate value, and is the most directly related [8]. Moreover, the use of EVA-related indicators reflects a new corporate value, which aligns the interests of managers and shareholders, and is consistent with the goal of maximizing corporate value, leading to the increasing wealth of companies and shareholders. EVA does not encourage enterprises to sacrifice long-term interests for short-term gains, and pays attention to the long-term sustainable development of companies. However, it is difficult to obtain better empirical results by using EVA directly. The value of EVA of different enterprises differs greatly in magnitude. Therefore, using the previous literature for reference and choosing total assets EVA can also eliminate the impact of enterprise size on EVA.

(4) Control variables. Under the environment of economic market development, there are many factors affecting enterprise performance and enterprise value. This paper is to study the impacts of employee stock ownership on enterprise performance and enterprise value. Therefore, we choose variables to measure enterprise size, asset-liability structure and enterprise growth as control variables. The details are as follows: equity concentration, company size, total asset growth rate, intangible assets proportion, corporate financial leverage, actual controllers, industry control variables, total asset turnover, operating profit margin.

(a) Equity concentration. Equity concentration shows the concentration or dispersion of corporate equity. The higher the concentration of equity, the more concentrated the controlling shareholders' shares, which is decisive for the strategic planning and decision-making of the entire company. The degree of equity concentration affects the controlling shareholder's supervision and

Table 1 Definition variables

Variable nature	Variable name	Description
Independent variables	Employee stock ownership	The ratio of employee shareholding to total share capital (PERCENTAGE)
		The proportion of employees participating in the shareholding plan to the total number of employees (RANGE)
Dependent variables	Corporate performance	Return on equity (ROE)
	Corporate value	The total assets EVA (EVAA)
Control variables	CR10	The sum of the shareholding ratio of the top ten shareholders and use it to measure equity concentration
	ASSETGRO	(Total assets for the year—total assets of the previous year)/total assets of the previous year
	DEBT	Total liabilities/total assets
	INTANR	Ln (Intangible assets/total assets)
	LNA	Ln (assets)
	LNIN	Ln (Operating income)
	CONTROL	CONTROL = 1 if actual controller is State-owned enterprise, CONTROL = 0 if not
	INDUSTRY	INDUSTRY = 1 if corporate is high-tech, INDUSTRY = 0 if not
	TAT	The total asset turnover rate
	INP	Operating profit rate

control of management, which affects management's business behavior and investment decisions, and affects corporate performance and corporate value. This paper selects the total shareholding ratio of the top ten shareholders of listed companies (CR10).

(b) Company size. The scale of a company represents the scope of production and operation of a company. Different companies have different available resources. The company with a larger company has more labor, machinery and equipment resources, and the more mature internal control mechanism, therefore, the performance and value of the enterprise will be better [9]. In order to more clearly observe the company size and empirical regression of the research samples, this paper uses the natural logarithm of total assets and operating income of listed companies to express the size of companies.

(c) Growth ability. The company's growth ability represents the company's future development. The higher the growth of the company, the greater its potential for future development, and its corporate performance will also increase significantly. This article uses the total asset growth rate (ASSETGRO) to indicate the company's growth.

(d) The proportion of intangible assets. Compared with non-high-tech companies, high-tech companies have higher R&D expenditures and higher human capital intensive characteristics, making them more demanding for technological innovation. Therefore, the control variable intangible assets accounted for the total assets ratio (INTANR) is added.

(e) Corporate financial leverage. The asset-liability ratio represents the capital structure and solvency of an enterprise, and shows the scale of the company's liabilities. Appropriate liabilities can improve the capital structure of enterprises, but in terms of long-term development, larger liabilities will increase the business risks of enterprises and affect corporate performance and corporate value. Therefore, this paper chooses the asset-liability ratio (DEBT) to represent the debt level of the enterprise as the control variable.

(f) The actual controller. State-owned enterprises are very vulnerable to government intervention, and their "internal control" is serious, which is not conducive to the improvement of corporate performance [10]. Therefore, the nature of the controlling shareholder will have a certain impact on the company's performance and corporate value. The degree of influence of employee stock ownership in state-owned enterprises and private enterprises on corporate performance and corporate value may be different. This paper divides the company's controlling shareholders (CONTROL) into two categories, namely state-owned holdings and non-state-owned holdings, state-owned holdings are assigned 1, otherwise 0.

(g) Industry control variable (INDUSTRY). According to the definition of high-tech enterprises by the National Bureau of Statistics, the industry with relatively high R&D investment intensity in the national economy is a high-tech enterprise. High-tech enterprises are 1, otherwise 0.

(h) The total asset turnover rate (TAT). TAT reflects the turnover rate of corporate assets. The higher TAT, the faster the asset turnover rate, the better the asset usage efficiency, and the better the company's operating performance.

(i) Operating profit rate (INP). INP is the ratio of the company's operating profit to total operating income. It is an indicator of the efficiency of business operations and reflects the ability of business managers to profit from operations in the context of operating costs.

3.4 Model Building

To verify Hypothesis 1, draw on the model set by the empirical research of Huang and Zhang for the performance of state-owned company employees' shareholding in Economic Science [3]. We replace the dependent variable EPS, ROA with ROE. The number of employees in the company is replaced by the number of participants in the proportion of all employees (RANGE), and the logarithm of the company's operating income is added to measure company's scale. In addition, the industry control variables are used as control variables. The specific model is as follows:

$$\begin{aligned} ROE = {} & \alpha + \beta_1 RANGE + \beta_2 PERCENTAGE + \beta_3 CR10 \\ & + \beta_4 ASSETGRO + \beta_5 DEBT + \beta_6 INTANR + \beta_7 LNA \\ & + \beta_8 LNIN + \beta_9 CONTROL + \beta_{10} INDUSTRY + \varepsilon \end{aligned} \tag{1}$$

To verify hypothesis 2, follow (1). Referring to the previous study of enterprise value, we replace the explanatory variable ROE with EVAA. Because the impact of firm scale has been eliminated, the control variables LNA and LNIN for firm scale are removed to avoid the effects of multi-collinearity. And ROE, total asset turnover, and operating profit margin are added as controlled variables. The specific model is as follows:

$$\begin{aligned} EVAA = {} & \alpha + \beta_1 RANGE + \beta_2 PERCENTAGE + \beta_3 CR10 \\ & + \beta_4 ASSETGRO + \beta_5 DEBT + \beta_6 INTANR \\ & + \beta_7 ROE + \beta_8 TAT + \beta_9 INP + \beta_{10} CONTROL \\ & + \beta_{11} INDUSTRY + \varepsilon \end{aligned} \tag{2}$$

4 Empirical Analysis

4.1 Descriptive Statistics

Before descriptive statistics, this paper first performed a 5% tail-tailing process to remove extreme values. For the overall samples, a total of 591 data were observed. The statistical results are shown in Table 2.

Table 2 reports descriptive statistics for each sample of the full samples. The minimum value of ROE is −6.350, the maximum value is 23.11, and the average is 8.629, which indicates that the business performance difference between enterprises is large. At the same time, the minimum value of EVAA is −0.066, the maximum is 0.085 and the average is 0.007, which means that the enterprise value between enterprises is also different. In addition, there is a difference between the ratio of employee stocks to total equity (PERCENTAGE) and the number of employees participating in stock ownership plans to total employees (RANGE).

Because this paper mainly studies the effects of employee stock ownership in high-tech industries and non-high-tech industry companies, the samples of listed companies that implement employee stock ownership in this paper are divided into two sub-samples of high-tech companies and non-high-tech companies. Descriptive statistics are provided separately, which is convenient for us to compare the two industries. The comparison results of descriptive statistics are shown in Table 3.

Table 2 Employee-owned companies descriptive statistics

Variable	Obs	Mean	Std. dev	Min	Max
ROE	591	8.629	7.196	−6.350	23.110
EVAA	591	0.007	0.040	−0.066	0.085
RANGE	591	14.013	13.457	0.490	48.980
PERCENTAGE	591	1.092	0.843	0.149	3.400
CR10	591	58.001	12.207	34.440	78.760
DEBT	591	39.115	17.757	12.051	72.106
INTANR	591	4.156	2.951	0.197	11.256
ASSETGRO	591	26.547	28.770	−5.423	102.806
LNA	591	22.236	0.934	20.660	24.018
LNIN	591	21.461	1.165	19.492	23.744
TAT	591	0.572	0.291	0.171	1.245
INP	591	9.608	9.308	−10.158	28.707
CONTROL	591	0.909	0.288	0.000	1.000
INDUSTRY	591	0.558	0.497	0.000	1.000

Table 3 Descriptive statistics by industry

Variable	High-tech (N = 330)		Non-high-tech (N = 261)	
	Mean	Std. dev	Mean	Std. dev
ROE	9.158	6.63	8.211	7.836
EVAA	0.008	0.045	0.006	0.059
RANGE	13.596	13.493	14.342	13.427
PERCENTAGE	1.164	0.796	1.036	0.896
CR10	61.321	12.033	55.375	11.625
DEBT	43.374	15.448	35.748	19.518
INTANR	3.923	2.704	4.341	3.225
ASSETGRO	23.899	29.746	28.642	27.314
LNA	22.415	0.85	22.094	1.003
LNIN	21.736	1.067	21.242	1.227
TAT	0.544	0.27	0.663	0.498
INP	8.738	17.296	17.473	86.761
CONTROL	0.862	0.227	0.945	0.345

In Table 3, the average value of the dependent variable ROE in the high-tech industry is 9.158, and the standard deviation is 6.63. The average value of the non-high-tech ROE is 8.211, and the standard deviation is 7.836. It can be seen that the return on net assets of high-tech industry companies is higher than that of non-high-tech industry companies, and the fluctuation is smaller. In addition, the average value of EVA of high-tech industry companies is higher and more stable than non-high-tech industry companies. The PERCENTAG of the high-tech industry is higher, but the RANGE is slightly smaller. It shows that companies in high-tech industry are more inclined to implement employee stock ownership than those in non-high-tech industry, give employees shares, encourage them to improve their work efficiency, and thus enhance the company's performance.

For the control variables introduced in this paper, the CR10, DEBT, LNA and LNIN of the high-tech industry are higher, indicating that the high-tech industry companies have higher equity concentration, larger enterprise scale and higher financial leverage. But INTANR, ASSETGRO, TAT and INP are slightly lower than those of non-high-tech industry companies, that is to say, the growth ability is slightly worse.

In summary, the effects of employee stock ownership on corporate performance and value vary among different companies. So, the specific implementation effect needs further testing.

4.2 Multi-collinearity Test

Before the panel data regression, it is necessary to test whether the model has multi-collinearity. In order to test the multicollinearity, the Variance Inflation Factor (VIF) is generally used for verification. VIF refers to the degree of dependence between variables. If the VIF value is large, it indicates that the variable has a more serious collinearity problem with other variables. It is generally considered that when $0 < VIF < 10$, there is no multicollinearity. In Table 4, the left two columns are the VIF of (1), and the right two columns are the VIF of (2). As can be seen from the

Table 4 Value of VIF

Variable	VIF1	Variable	VIF2
LNA	5.2	ROE	3.98
LNIN	4.68	INP	3.32
DEBT	1.87	TAT	1.9
RANGE	1.16	DEBT	1.4
INDUSTRY	1.16	INDUSTRY	1.16
CR10	1.13	ASSETGRO	1.16
CONTROL	1.12	CR10	1.13
ASSETGRO	1.12	CONTROL	1.09
INTANR	1.07	RANGE	1.07
PERCENTAGE	1.03	INTANR	1.06
		PERCENTAGE	1.03
Mean VIF	1.96	Mean VIF	1.66

results, the data does not have a multicollinearity problem, because the VIF of all independent variables and control variables are less than 10, so panel data regression can be carried out.

4.3 Empirical Results

(1) *Employee Stock Ownership and Corporate Performance*

Table 5 shows the results of multiple regression of (1). First, look at the regression of the first full samples. From the value of F and R^2, the overall fitting effect of (1) is good, and the equation as a whole is significant. The regression coefficients of the explanatory variables PERCENTAGE and RANGE are both positive, the shareholding ratio is significant at the significant level of 5%. The regression coefficient of RANGE is not significant, but it can still be seen that the higher the employee shareholding ratio is, the higher the ROE of the company is, that is, the better performance of the company is, thus verifying the H1: the implementation of employee stock ownership by listed companies has a positive impact on the company's performance.

Comparing the regression results of high-tech companies and non-high-tech companies, the former PERCENTAGE and RANGE have a positive correlation with ROE, while the latter has a negative correlation with ROE, which indicates that

Table 5 Multiple regression results of employee stock ownership and ROE

Variable	ROE of full samples	ROE of high-tech samples	ROE of non-high-tech samples
RANGE	0.009	0.047	−0.009
PERCENTAGE	0.607**	0.747*	−0.189
CR10	−0.046**	−0.06	−0.044*
DEBT	−0.049***	−0.072**	−0.042*
INTANR	0.192**	0.245*	0.017
LNA	−1.885***	−0.649	−3.354***
LNIN	4.673***	3.928***	5.812***
ASSETGRO	0.064***	0.084***	0.053***
CONTROL	0.804	3.762***	−0.832
INDUSTRY	0.279		
_cons	−50.496***	−60.826***	−45.432***
N	591	330	261
Adj-R^2	0.362	0.364	0.389
F	35.51	17.5	24.24
Prob > F	0	0	0

Note * corresponds to significant at 10%; ** significant at 5%; *** significant at 1%

the effects of the implementation of employee stock ownership on the performance of high-tech enterprises and non-high-tech enterprises are different and the effects of high-tech enterprises in implementing employee stock ownership are better than non-high-tech enterprises.

(2) *Employee Stock Ownership and Corporate Value*

Table 6 shows the results of multiple regression of (2). The regression results of the whole samples show that the R^2 of (2) is 0.7035, and the F value is 128.28 (P = 0.0000), indicating that the model is well fitted and there is a significant correlation between the interpreted variable and the explanatory variable as a whole. Among them, the explanatory variables RANGE and PERCENTAGE are significantly positively correlated with the explanatory variables at the significant level of 5%, indicating that EVAA rate and the economic value increase as the number of participants accounts for the total number of employees and the proportion of shares held growing. It means that the market value of the enterprise and the growth of shareholder wealth are assumed to be verified by H2. Comparing the high-tech and non-high-tech companies, the RANGE coefficients of both are positive, but the former is greater than the latter. About the PERCENTAGE coefficient, the former is positive and significant, while the latter is negative, indicating that the effects of high-tech enterprises and non-high-tech enterprises on the implementation of employee stock ownership has different effects. Further, the effects of high-tech enterprises

Table 6 Multiple regression results of employee stock ownership and EVAA

Variable	EVAA of full samples	EVAA of high-tech samples	EVAA of non-high-tech samples
RANGE	0.00015**	0.00015	0.00004
PERCENTAGE	0.00226**	0.00573***	−0.00183
CR10	−0.00004	−0.00002	0.00005
DEBT	0.00019***	0.00024**	0.0001
INTANR	0.00042	0.00078	0.00022
ASSETGRO	−0.00020***	−0.00019***	−0.00021***
ROE	0.00382***	0.00435***	0.00338***
TAT	0.0204***	0.00739	0.0313***
INP	0.00074***	0.00019	0.00133***
CONTROL	0.0112***	0.00556	0.0113***
INDUSTRY	0.00764***		
_cons	−0.0651***	−0.0523***	−0.0678***
N	591	330	261
Adj-R^2	0.7035	0.6214	0.816
F	128.28	55.01	116.33
Prob > F	0	0	0

Note * corresponds to significant at 10%; ** significant at 5%; *** significant at 1%

in implementing employee stock ownership are better than that of non-high-tech enterprises.

5 Robustness Test

5.1 Building Cross Terms

To test whether the empirical results of H1 are robust, the continuous variables RANGE and PERCENTAGE are first centrally normalized before constructing the interaction term, and then the interaction terms are constructed with INDUSTRY. This can avoid the effects of severe multi-collinearity. The centralized continuity variable is used in the construction of interactive items. When incorporating the model, the individual continuity variables still use the raw data. Observing the robustness results, PERCENTAGE has a significant positive effect on ROE when controlling the INDUSTRY. Hypothesis 1 is verified.

5.2 Replacing the Interpreted Variable

In order to further verify whether the empirical results of this paper are robust, replace the ROE with EPS in the robustness test section and substitute (1) to re-run the regression test. The test results still have not changed the original conclusion. It can be seen from the test results of the two methods that the main conclusions of (1) regression have not changed substantially, that is, the regression results of (1) are robust, and the incentive effect of employee stock ownership is significant. Hence, hypothesis 1 is verified.

In order to verify whether the empirical result of (2) is robust, replace EVAA with EVA per share, substitute (2) and perform regression test again. The test results show that unless the regression coefficient of the proportion of participants in the high-tech samples become negative, the direction of the regression coefficients of other explanatory variables does not change, at the same time the significance is similar. So the regression results for (2) are robust, the wealth effect of employee stock ownership is significant, which means hypothesis 2 is verified.

6 Conclusion

This paper takes the data of a-share listed companies over the period 2015 to 2017 as the research object, and conducts an empirical study on the economic effects of employee stock ownership on the company. The results confirm that the company implements employee stock ownership, on the one hand, it plays an incentive role for employees, encourages employees to actively play the role of human capital, and enhances work enthusiasm, thereby improving company performance and corporate value. On the other hand, due to the interests of employees and the interests of other shareholders, the development of the company is consistent, the employees have the incentive to supervise the managers. In the actual business process, that can reduce the management's behaviors that damage the interests of shareholders due to information asymmetry, increase the enterprise's value and shareholder's wealth, as well as enable managers to share more profits with more efficient management measures. In addition, cause high-tech enterprises pay more attention to the investment of human capital, which has the characteristics of high investment, high growth, high risk and high profit, the empirical results show that high-tech enterprise is more effective than the non-high-tech enterprise to implement employee stock ownership.

The conclusions of this paper have the following two meanings: On the one hand, the previous researches on the effects of employee stock ownership have been studied from the aspect of corporate performance or corporate value. This paper comprehensively examines the impacts of employee stock ownership on corporate performance and corporate value, which can more comprehensively portray the effects of employee stock ownership. On the other hand, this paper conducts a group test based on the industry as a standard, and conducts a comparative study on the effects of employee stock ownership between high-tech enterprises and non-high-tech enterprises. It is found that the effects of high-tech enterprises in implementing employee stock ownership are more significant. That conclusion enriches the relevant research on the implementation of employee stock ownership analysis in different industries.

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Cultural Risk Research on Overseas Merger and Acquisition of Chinese Petroleum Enterprise

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Abstract Cultural risk is one of the major risks of Chinese oil companies' overseas merger and acquisition. The root cause of cultural risk lies in cultural differences. Differences in the political factors, laws and regulations, religions, business environment, business rules, and corporate culture of host countries will inevitably lead to the emergence of ethnic cultural risks, commercial cultural risks, and corporate culture during overseas merger and acquisition. Due to the different characteristics of state-owned oil companies and private oil companies, the main types of cultural risks faced in overseas mergers and acquisitions are also different. "Western model", "Central Asian model" and "Middle East model" are the most common overseas merger and acquisition models of oil companies. Using SWOT risk analysis method, the impact of various cultural risks and the appropriate strategies can be analyzed and developed. The degree of cultural risk in different modes can be assessed to provide reliable strategies or overseas merger and acquisition of oil companies based on the analytic hierarchy process (AHP).

Keywords Overseas merger and acquisition · Risk sources · Risk analysis · Risk assessment · SWOT · AHP

1 Introduction

The conflict between oil supply and demand is deepening with China's economic development and the urbanization process accelerating. China's oil companies have limited production capacity and are increasingly dependent on oil imports [1]. By 2018, China's oil imports accounted for 70% of total consumption. In order to ensure

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the healthy development of the national economy and national strategic security, China's oil companies have to actively seek to develop overseas market, further expand the scale of overseas investment for increasing the supply of overseas oil and gas. At present, CNPC overseas oil and gas operations have expanded to over 30 countries. Since 2014, international oil prices have continued to fall from a high level, which has caused great impact on the entire oil industry. Although the current oil price has rebounded, the future prospects of the oil industry are still unclear due to changes in the international political situation. This is both an opportunity for development and a challenge for overseas oil investors of Chinese oil companies. There are various risks in the M&A process, of which cultural risk is one of the most important risks.

Because overseas M&A originates from multinational corporations in developed countries, the study of cultural risk in overseas mergers and acquisitions is usually based on the Western culture. As a country with a long history of culture, China's influence has been increasing. However, there are still significant culture differences between China and Western countries, countries in the Middle East, and neighboring countries. These differences are not only reflected in differences in national culture such as political systems, legal construction, religions, and social customs, but also in corporate values, management systems, business practices, and business ethics. It is difficult for foreign companies to recognize and accept the culture of Chinese companies and the national culture they represent. Therefore, Chinese oil companies' overseas M&A inevitably faces multicultural conflicts. How to correctly understand and identify the cultural risks in the process of overseas M&A and actively adopt coping strategies to enhance the company's ability to resist risks is an important issue of Chinese oil companies.

Although people have recognized the importance of cultural risk for overseas mergers and acquisitions, culture has complex attributes of politics, law, morality, customs, and other human capabilities, and its risk identification and evaluation is very difficult for business decision makers. The target markets for overseas acquisitions by Chinese oil companies are relatively complex [2]. There are not only oil companies in developed countries such as Europe and the United States, but also some oil companies in Asia, Africa, and Latin America with unstable political situation and backward economy. The national culture, commercial culture, and corporate culture of enterprises in these countries are quite different from those of Chinese oil companies. Using effective methods and techniques to identify and assess cultural risks is crucial to reducing the risk of overseas mergers and acquisitions and increasing the success rate of investments.

2 The Cultural Risk Source of Petroleum Enterprise Overseas M&A

Culture is a group of thoughts, ideas, behaviors, customs, habits formed in a certain period of time, and all activities radiated by this group's overall consciousness [3]. People in different societies cannot be separated from the far-reaching influence of the social, cultural, ethnic, regional, religious and other social cultures of the society in which they live. They are also influenced by the corporate culture that their companies bring them. The source of cultural risk mainly comes from three aspects including national culture, commercial culture and corporate culture. National cultural is a cultural tradition formed by a nation in the course of historical development. Its reflection in real life is multifaceted and often ingrained. Ethnic culture mainly includes institutional and spiritual cultural achievements. Institutional achievements that mainly refer to theoretical forms of expression are a set of normative systems based on certain social relationships, including political systems, laws and regulations. The spiritual cultural achievements are mainly reflected in the social cultural aspects such as religious beliefs, customs and people's values, which have a profound influence on people's cognition and behavior [4]. In the cross-border mergers and acquisitions of Chinese oil companies, Western developed countries will be affected by Chinese national culture. Western countries that always regard Western culture as an advantage culture will inevitably appear to be unsuitable, and set obstacles to M&A in terms of national security, laws and regulations. With the development of globalization, the political, economic, and cultural exchanges and cooperation of various countries have become deeper and deeper, and their influence on each other has also grown. The politics and economy of less power countries will be interfered with by developed countries, and their culture will also be eroded by foreign cultures. Even the superpowers will inevitably be affected by the international situation. Because of the importance of petroleum resources, some of the major petroleum producing countries in the Middle East and South America are often places where some big countries are wrestling. Major countries for economic needs and political goals determine the policy direction of these oil-producing countries to a certain extent.

Business culture is the gradual formation of specific business ideas and behaviors in the long-term business activities. It is an extension of national culture to some extent and is restricted by national culture. Business culture involves business environment, business ethics and business rules. In the process of overseas mergers and acquisitions, due to different cultural backgrounds, different business environments, and differences in business concepts, M&A parties have different ways of understanding and responding to the same thing or phenomenon, which results in misunderstandings or even conflicts in the interaction. At present, the oil industry is in a relatively low tide, oil price has been hovering low, and the outlook for the oil industry remains uncertain. Although the cost of mergers and acquisitions has dropped significantly, investors are cautious about overseas mergers and acquisitions in the current international oil business environment. At the same time, the business environment of the countries where the companies are purchased is quite different, especially in some oil-producing countries in the Middle East. Due to the unstable political situation, the immature financial markets, and the inability of commercial credit, it will also bring great commercial risks to investors. In the later stages of M&A transactions, the differences between the business ethics, business rules, and business practices of M&A parties can also lead to failure of the company's operations. Chinese companies usually pay more attention to their relationships when they are in business, and then consider business rules and legal requirements. The business activities of western companies are based on legal and business principles. Chinese companies tend to focus only on the results, and as a result, they can ignore the details of mistakes. Western companies value the details of the business process. They think that the process is reliable and the results will follow.

Corporate culture mainly refers to the organizational culture of all employees and managers of a company, such as business philosophy, values, management philosophy, and behavioral norms. Mergers and acquisitions parties are in different corporate culture systems. Each mature company has its own corporate value concept. Under a specific corporate culture, the management style of the company is very different, and the employees of the company will also form their own values, codes of conduct. The employees not only have a high degree of recognition of their corporate culture, but also maintain a high degree of recognition of their own culture. The enterprises of overseas M&A will inevitably face the cultural conflicts brought about by the collision of enterprise culture.

Enterprise culture mainly includes spirit culture and system culture. Enterprise spirit culture refers to a kind of spiritual achievement and cultural concept that has been formed for a long time by enterprises in the process of production and management under the influence of certain social and cultural background and ideology [5]. The enterprise spirit culture is the core of the enterprise culture, which includes the values of the enterprise and the behavior culture of employees who use it as a guiding ideology. Due to the differences in the specific growth background, business philosophy, operating environment and resources of each company, the enterprise spirit culture is also different. As the ideological and behavioral standards of companies and employees, the enterprise spirit culture is hard to be changed, and spiritual culture conflicts often bear the brunt of corporate mergers and acquisitions. The enterprise behavior culture is the external performance of the company's management style, leadership management methods, interpersonal relationships, which is also an intrinsic embodiment of the corporate value. The employees of the host company tend to reject and resist the new corporate culture, so as to resist the invasion of other corporate cultures in order to maintain the superiority of their spiritual culture. The system of the enterprise culture is an important part of enterprise culture. It is a system and norm that is used to regulate the behavior of employees in an enterprise, and generally includes the leading system, organization and management system of the enterprise [6]. The enterprise system culture is the product of the enterprise's spiritual culture, because people are always guided by certain values to improve and improve the company's various systems. However, institutional culture also affects this corporate culture. Due to the long-term impact of the original management system, leadership system, and behavioral norms, it is difficult for the employees host company to adapt to the changes in organizational structure the adjustment of the original rules of the enterprise after mergers and acquisitions. The employees have a low degree of recognition, and will be intentional or unintentional resistance to the new system.

3 SWOT Analysis of Cultural Risk in Chinese Oil Companies Overseas M&A

3.1 Cultural Risk Models of Oil Company Overseas M&A

The strategy of going global for Chinese oil companies has been implemented for more than 20 years. There are three main modes of overseas mergers and acquisitions. The first is the "Middle East model." The socio-political environment of the host countries is turbulent, and the industrial foundation is weak, and customs and habits are different. However, their oil resources are abundant. The second is the "Central Asian model". The host countries have better geopolitical relations with China, and the oil transportation is convenient. The third type is the "Western model." Western developed countries have a high level of cultural maturity and a relatively complete corporate culture system. Different M&A models have different cultural risk characteristics. In general, different M&A models have different cultural risk characteristics.

3.2 SWOT Analysis for Different Cultural Risk Models

SWOT analysis is often used to formulate the development strategy and analyze the situation of competitors. In the risk analysis, it is one of the most commonly used methods. From the perspective of the external environment, the continued downturn in the petroleum industry provides a good opportunity for Chinese companies overseas M&A. As the largest energy importer, China is one of the largest energy demand countries and has huge market demand. Oil companies in oil-producing countries are eager to cooperate with Chinese companies. At the same time, due to energy security considerations, the overseas development of oil companies is strongly supported by the Chinese government. Especially in the "One Belt And One Road" environment, Chinese oil companies' overseas investment is supported not only by the Chinese government but also by the government of neighboring countries. It can solve China's energy shortage and promote the common development of the local economy of the host countries. The threat of overseas mergers and acquisitions cultural risks also needs to be vigilant. The long-term political instability in the Middle East has led to the emergence of ethnic cultural risks. The agreement signed with the ruling party may become a waste of paper after the opposition political party come to power. The relevant legal systems in some countries in the Middle East are not perfect, which is very unfavorable to deal with the disputes in the merger and acquisition process and management.

From the analysis of internal factors, the advantage of overseas M&A cultural risk is that Chinese state-owned petroleum enterprises have better financial credit and decision-making mode, and can quickly organize the operation of projects with low human and material costs. Petroleum exploration and development technology originated from western countries, so multinational companies from developed countries have obvious technological advantages. At the same time, most of these companies have experienced decades or even hundreds of years of corporate culture precipitation, and the enterprise organization structure and management system are more reasonable.

However, in the process of management and operation, Chinese oil companies prefer to be people-oriented and emphasize the relationship between people. Western oil companies tend to use the system as the principle and use the system to restrict employees' behavioral norms. Western oil companies value the interests of employees and protect the reputation of the company. They will not achieve their own performance through unpaid overtime work, nor will they win the bribe by bribery. Differences in religion and customs can lead to conflicts in the organization and culture of companies. The hard work of the Chinese is in contrast to the relatively free work style of local employees. There is a great difference in the aspect of enterprise management between Chinese employees who bear hardship without complaint and those with their work habits from the host countries, and the differences in corporate culture will inevitably bring problems to the management of the later stages of mergers and acquisitions.

3.3 Countermeasures of Cultural Risk Based on SWOT

For different M&A models, give full play to the dominant factors, analyze and overcome the inferior factors; make better use of opportunities, identify and evade threats. For the cultural risks in the M&A of the "Middle East model", Chinese oil companies use W-O countermeasures, which focus on opportunity factors and weaknesses to maximize opportunities and minimize weaknesses. After all, the period of the low tide of the entire oil industry will remain unclear. The export of petroleum resources is the most important economic pillar of the Middle East countries. The Middle East countries must rely on China's huge oil demand market. On the other hand, as long as Chinese oil companies fully respect their customs and religious culture, the conflicts of corporate culture will naturally weaken. The ST strategy is relatively suitable for the merger of the "Central Asian model". Central Asian oil companies are happy to enjoy the economic vitality brought by Chinese companies, and Chinese companies can also get reliable oil supply guarantees from neighboring countries. At the same time, Chinese oil companies in Central Asia have to face competition with Western companies. For the “Western model”, the WT strategy may be a good choice. Mergers and acquisitions of Western oil companies need to be cautious. Not only do Western political concepts, laws, and social environments create resistance to Chinese oil companies’ mergers and acquisitions, but Western oil companies’ strong corporate culture also interferes with later operations.

At this stage, Chinese oil companies are cautious about adopting “Western models” of overseas mergers and acquisitions. The main threat comes from the fact that Western developed countries are hostile to the rapid development of China. They believe that Chinese companies may have ulterior motives for the acquisition of strategic resources. Therefore, the overseas mergers and acquisitions of Chinese oil companies in Western developed countries are often hindered by various aspects. However, once the acquisition is approved by western governments, its standardized commercial operation will make the merger progress smoothly. The relatively abundant capital of Chinese oil companies and Chinese government policy and economic support can help western oil companies escape the financial difficulty in the low oil price period. The advantage of the “Western model” is that Chinese oil companies can not only learn advanced management experience and business concepts, but also introduce and utilize advanced technologies from Western enterprises. However, there are certain disadvantages in adopting the “Western model” when integrating Western corporate culture. In the process of management and operation, on the one hand, Chinese oil companies prefer human-oriented, emphasizing the relationship between people. Western oil companies tend to use the system as the principle to restrain employees’ code of conduct [7]. On the other hand, Chinese oil companies focus on maximizing collective profits. Western oil companies attach importance to the interests of employees and protect the reputation of enterprises. They will not realize their own performance through unpaid overtime, nor will they win profits by offering bribes.

4 The AHP Application in Cultural Risk Assessment on Overseas M&A of Chinese Petroleum Enterprise

AHP (Analytic Hierarchy Process) is a practical multi-scheme and multi-objective decision-making method put forward by American operational researcher T. L. Saaty in the 1970s. It is a qualitative and quantitative decision analysis method [8]. It is often applied to multi-objective, multi-criteria, multi-factor, multi-level complex problems, especially strategic decision-making issues, and has a very wide applicability.

When using AHP to solve all kinds of decision problems, the complex problem should first be decomposed into several components, and then different components should be grouped according to classes. Finally, a multi-level evaluation model is established based on the grouping situation. According to the analysis of risk sources and the identification of risks, the cultural risk assessment index system of Chinese oil companies’ overseas M&A is constructed. In this paper, the cultural risk of overseas

M&A is taken as the target level, and some major risks involved in national culture, business culture, and corporate culture are taken as the criterion level. The main risks include political factors, laws and regulations, religious customs, business environment, commercial marketing, business ethics, corporate values, corporate systems, employees' behavioral culture, etc. Three types of overseas M&A which includes the Western model, the Central Asia model, and the Middle East model are served as the programmatic layers (Fig. 1).

According to the above hierarchy, the 1–9 scale method is adopted to construct a judgment matrix using expert scoring. In this study, some experts from the oil industry, cultural institutions, and venture capital industry were invited to score the weights of overseas M&A cultural risk indicators. All members will score points based on their understanding of the various risk indicators and compare the importance of each. According to the established hierarchical model, the judgment matrix(A) of each element relative to the total target are established, as shown in Table 1. This matrix is used to describe the relative importance of each element in the criterion layer relative to the upper element.

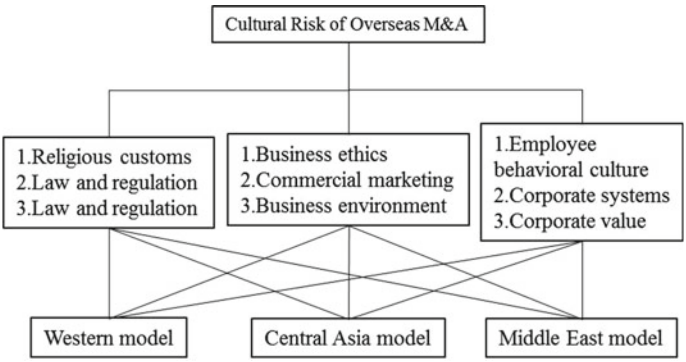

Fig. 1 Analytic hierarchy process model

Table 1 Judgment matrix(A)

A	B1	B2	B3	B4	B5	B6	B7	B8	B9
B1	1	3	7	4	5	6	2	5	8
B2	1/3	1	5	2	3	4	1/2	3	6
B3	1/7	1/5	1	1/4	1/3	1/2	1/6	1/3	2
B4	1/4	1/2	4	1	2	3	1/3	2	5
B5	1/5	1/3	3	1/2	1	2	1/4	1	4
B6	1/6	1/4	2	1/3	1/2	1	1/5	1/2	3
B7	1/2	2	6	1/3	4	5	1	4	7
B8	1/5	1/3	3	1/2	1	2	1/4	1	4
B9	1/8	1/6	1/2	1/5	1/4	1/3	1/7	1/4	1

The maximum eigenvalue and eigenvector of the judgment matrix are calculated by the summation method.

The judgment matrix (A) is normalized (that is, the sum of the column elements is 1). The values in the normalized matrix are summed in rows:

$$\mathrm{S_i} = \sum \left(\mathrm{A_{ij}} \middle/ \sum \mathrm{A_{ij}}\right) \tag{1}$$

In the Eq. (1), i and j are from 1 to 9.

By normalization of S_i, the normalized eigenvector of the maximum characteristic root of matrix A is obtained as the weight vector.

$$\mathrm{w_i} = \mathrm{S_i} / \sum \mathrm{S_i} \tag{2}$$

$$\begin{aligned} \mathrm{w^A} &= \{\mathrm{w_1}, \mathrm{w_2}, \ldots, \mathrm{w_9}\}^{\mathrm{T}} \\ &= \{0.32, 0.16, 0.03, 0.10, 007, 0.05, 0.09, 0.07, 0.02\}^T \end{aligned} \tag{3}$$

Where, the maximum eigenvalue:

$$\lambda max = \frac{1}{9} \sum \left(\frac{(AW)i}{Wi}\right) = 9.17 \tag{4}$$

According to the principle of the analytic hierarchy process (AHP), the consistency between the maximum eigenvalues λ max of matrix(A) and n is tested for consistency. The eigenvector corresponding to the largest eigenvalue is used as the weight vector of the effects of the compared factor on a certain factor in the upper layer. The greater the degree of inconsistency, the greater the judgment error caused.

$$\mathrm{CI} = \frac{\lambda max - 9}{9 - 1} = (9.17 - 9)/8 = 0.0213 < 0.1 \tag{5}$$

$$\mathrm{CR} = \frac{CI}{RI} = \frac{0.0213}{01.45} = 0.014 < 0.1 \tag{6}$$

Here CI is the consistency index, CR is the random consistency index, and n is the matrix dimension. RI is the Coincidence index for different dimension matrix.

The average random conformance index of the same order is shown in Table 2, and RI is equal to 1.45. It is generally believed that the consistency of judgment matrix is acceptable when CI is less than 0.1 and CR less than 0.1.

Table 2 Coincidence index of judgment matrix

n	3	4	5	6	7	8	9	10	11
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Table 3 National cultural risk judgment matrix

B1	C1	C2	C3	B2	C1	C2	C3	B3	C1	C2	C3
C1	1	2	7	C1	1	1/3	1/2	C1	1	4	5
C2	1/2	1	6	C2	3	1	1/2	C2	1/4	1	2
C3	1/7	1/6	1	C3	2	2	1	C3	1/5	1/2	1

Similarly, the judgment matrix B1, B2, B3, B4, B5, B6, B7, B8 and B9 of each element of the scheme layer relative to the criterion layer can be obtained as follows (Tables 3, 4 and 5):

Similar to the calculation process of judgment matrix (A), the characteristic roots, eigenvectors and consistency tests of matrix B1, B2, B3, B4, B5, B6, B7, B8 and B9 are obtained as follows:

After obtaining the relative importance of each level, we can calculate the overall importance of the factors at all levels by top-down processing (Table 6).

Table 4 Business cultural risk judgment matrix

B4	C1	C2	C3	B5	C1	C2	C3	B6	C1	C2	C3
C1	1	1/2	1/3	C1	1	3	5	C1	1	5	3
C2	2	1	1/2	C2	1/3	1	3	C2	1/5	1	1/3
C3	3	2	1	C3	1/5	1/3	1	C3	1/3	3	1

Table 5 Corporate cultural risk judgment matrix

B7	C1	C2	C3	B8	C1	C2	C3	B9	C1	C2	C3
C1	1	3	5	C1	1	6	4	C1	1	6	3
C2	1/3	1	3	C2	1/6	1	1/3	C2	1/6	1	1/3
C3	1/5	1/3	1	C3	1/4	3	1	C3	1/3	3	1

Table 6 Parameters of judgment matrix(Bi)

$w_1^B = \{0.59, 0.33, 0.08\}$	$\lambda max = 3.08$	CR = 0.069
$w_2^B = \{0.16, 0.30, 0.54\}$	$\lambda max = 3.01$	CR = 0.01
$w_3^B = \{0.68, 0.20, 0.12\}$	$\lambda max = 3.02$	CR = 0.02
$w_4^B = \{0.16, 0.30, 0.54\}$	$\lambda max = 3.01$	CR = 0.008
$w_5^B = \{0.63, 0.26, 0.11\}$	$\lambda max = 3.04$	CR = 0.03
$w_6^B = \{0.63, 0.11, 0.26\}$	$\lambda max = 3.04$	CR = 0.03
$w_7^B = \{0.63, 0.26, 0.11\}$	$\lambda max = 3.04$	CR = 0.033
$w_8^B = \{0.69, 0.09, 0.22\}$	$\lambda max = 3.05$	CR = 0.05
$w_9^B = \{0.65, 0.10, 0.25\}$	$\lambda max = 3.02$	CR = 0.02

$$
\begin{aligned}
\mathrm{w} &= w^{B} * w^{A} \\
&= \left\{ \left(w_1^B\right)^T, \left(w_2^B\right)^T, \cdots, \left(w_9^B\right)^T \right\} * w^A \\
&= \{0.50, 0.27, 0.23\}
\end{aligned} \tag{7}
$$

Based on the perspective of comprehensive evaluation, the western model is still the preferred mode from the perspective of cultural risk.

5 Conclusion

There are many cultural risks in the overseas mergers and acquisitions of Chinese oil companies. The differences in ethnic culture, business culture, and corporate culture may bring certain risks to overseas mergers and acquisitions and involve all aspects of the M&A process. It is necessary not only to do in-depth research on the source of cultural risk, but also to identify different types of cultural risks by using effective methods.

The cultural risks in the overseas mergers and acquisitions of oil companies are multi-faceted. Differences in national culture, business culture and corporate culture may bring certain risks to overseas mergers and acquisitions and involve all aspects of the M&A process. The motives of overseas M&A by Chinese oil companies are often easily questioned, and they are particularly vulnerable to political interference of the host country. State-owned oil companies should be more open-mined in the process of overseas M&A to create more benefits for the enterprises and their host countries, and to obtain the understanding of the host government and the public. Privately-owned oil companies are small in scale, and their business culture and corporate culture are not mature enough. They should take the initiative to cross-cultural exchanges for absorbing and learning foreign advanced management experience and business model, and achieve the integration of the culture of M&A parties.

The assessment of the cultural risk of overseas M&A of Chinese oil companies requires not only an in-depth analysis of the connotations and root causes of cultural risks, but also different approaches to different types of cultural risks for different modes. Using SWOT analysis and AHP method to analyze cultural risks in overseas M&A is a good risk assessment method. By analyzing the degree of cultural risk in overseas mergers and acquisitions under different modes, the negative impact of cultural risks can be reduced and overseas investors can be helped for optimization decision. Due to the diversity of sources and types of cultural risks, accurate identification of cultural risks and establishment of a reasonable assessment of cultural risks have yet to be tested in more practice.

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Does the Corporate Governance Status and Its Changes Affect the Auditor's Major Misstatement Risk Judgment?

Yuting Feng, Xuemeng Guo, and Hongchang Li

Abstract This paper first analyzes the theory and explains the two concepts of corporate governance and auditing major misstatement risks, and expounds their respective connotations and characteristics. Secondly, the theoretical basis between them is mentioned and the connection between the two is formed. The empirical tests were carried out from two perspectives. The first is the correlation between corporate governance status and the risk of major misstatement of auditing. The second is the auditor's multiple responses to different corporate governance levels. Taking the shareholding ratio of the first largest shareholder, the size of the board of directors, the dual roles of the chairman and the general manager, and the size of the board of supervisors as the substitute variables for corporate governance; whether the company is punished by the CSRC to indicate the risk of material misstatement, and the change in audit fees Representing the auditor's response to changes in behavior. Finally, the empirical results were discussed and the results that were inconsistent with the expected assumptions were analyzed. Suggestions on optimizing the shareholding structure, taking into account the size and independence of the board of directors, and strengthening the effectiveness of the board of supervisors are given in the current situation in China.

Keywords Corporate governance · Material misstatement risk · Audit risk response · Correlation

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1 Introduction

A vicious incident of frequent financial fraud in listed companies in China. From Huxi Plastics to Dongfang Electronics and Dongfang Boiler, financial scandals follow one after another. Although this series of events has aroused widespread concern about the phenomenon of fiscal fraud in the community, it has also deeply hurt the capital market itself, and has damped the enthusiasm of investors for entering the market, which led to the distrust of China's capital market. Suspicion of flooding has seriously affected investment enthusiasm. In such a market situation, relying solely on existing systems and methods may make it difficult to restore investor confidence, and it is difficult to truly establish a healthy and benign market environment. How to carry out economic system reform, how to carry out corporate governance, how to correctly guide the development of the market and enterprises has become a key topic of widespread concern. How to supervise the performance of the auditing company's duties in auditing the company, how to ensure that the auditing company completes the corresponding tasks in ensuring the correct and detailed accounting information of the company has become a necessary link to reduce or even eliminate the vicious incident of financial fraud. Therefore, paying attention to the quality of auditing and paying attention to auditing risks has become a new topic. Under the old systems and norms, how to improve the current auditing system, how to run the existing auditing model, how to ensure the scientific and effective auditing, and to carry out innovation and research and exploration in the way of auditing have become new challenges.

As people's growing concern about corporate governance has led to the division of governance status of domestic and foreign scholars, the measurement of the level of governance, the analysis of the earnings management motivation analysis caused by governance defects, in addition, the auditor's behavioral changes are also needed scholars and practitioners are concerned. It is impossible to distinguish behavior from reality, because the cost criteria for conducting audit work, audit feedback and adjustment and revision opinions, and the audit company's quality of audit work are central factors. However, the existing literature on this work is often divided into discussions. Scholars at home and abroad have not well extracted the relevance of them. It may be due to different industries, different regions and countries, or the relevant information is too complicated to summarize. But this may be the key to solving the audit problem. Therefore, this paper will combine the specific actual situation, the theoretical research and empirical test on the correlation between corporate governance and auditing material misstatement risk and the auditor's response behavior to different corporate governance.

2 Literature Review

As mentioned above, in the process of collating and researching relevant literature, it is difficult to find information on articles and related research that are concerned about the company's management control system and financial fraud and financial system defects. More literature only pays attention to one of them, and did not combine the two organically and comprehensively consider the interaction between them. By combing and analyzing the various articles and materials mentioned above, we can find that these related researches have strong guidance for the research of this paper, and also provide ideas and basic foundation for the research of this paper. Therefore, based on the ideas and ideas of the predecessors, this paper will analyze the relationship between the two and the specific situation of the major error, and analyze the relationship between them and the mutual influence, and analyze the model by establishing a model. Give relevant advice and ways to reduce fiscal fraud.

2.1 Research on Correlation Between Corporate Governance Characteristics and Major Misstatement Risks

For the study of corporate governance characteristics and major misstatement risks, foreign scholars are earlier than domestic. Beasley wrote in his research that the number of independent directors in the company, the number of shares held by independent directors, and the term of the independent directors has an impact on the authenticity of the company's published financial statements, and the former is positively related to the authenticity of the financial report, and the latter two are negatively correlated [1]. In recent years, domestic related research has also begun to rise. Lu and Liu took the data of listed companies from 2001 to 2006 as a sample, the six major corporate governance characteristics, the establishment of the audit committee, the corporate debt ratio, and other major corporate misreporting risks the relationship has been empirically studied [2]. The study found that the higher the concentration of equity of the largest shareholder, the smaller the risk of material misstatement; the smaller the risk of material misstatement of listed companies with audit committee; the greater the ratio of short-term liabilities, the major misstatement the greater the risk, the greater the long-term debt ratio and the lower the risk of material misstatement. From the existing literature, the company's corporate governance structure and major misstatement risks are mainly studied from three aspects: equity structure, board structure, and board of supervisors.

1) *Correlation between ownership structure characteristics and major misstatement risks*

Meng conducted an empirical study of 259 A-share listed companies penalized by the China Securities Regulatory Commission, the Shanghai Stock Exchange, the Shenzhen Stock Exchange and the Ministry of Finance from 2006 to 2010.

The shareholding ratio of the largest shareholder and the audit of financial reports were found. There is a positive relationship between risks, and the mutual checks and balances of equity are inversely related to the audit risk of financial reports [3]. Xu conducted an empirical study on 316 A-share listed companies punished by the Securities and Futures Commission, the Shanghai Stock Exchange, the Shenzhen Stock Exchange and the Ministry of Finance for four years. The shareholding ratio of the largest shareholder and the audit risk of financial reports existed. To the relationship, the lower the proportion of outstanding shares, the less likely the listed company's financial statements to have a material misstatement, but it is significantly positively correlated with the concentration of ownership [4].

2) *Correlation between board structure and material misstatement risk*

Huang conducted an in-depth study on the relationship between the structure of the board of directors and the risk of material misstatement. It was found that the size of the board of directors and the proportion of independent directors in the board of directors were all negatively correlated with the risk of material misstatement. The chairman of the listed company and the general manager are at great risk of material misstatement. When a listed company establishes an audit committee, the risk of material misstatement is small [5]. Guo is based on data from the Securities and Futures Commission in the four years from 2010 to 2013, after excluding the factors of the industry and the impact of the economic environment on the company, the study found that the number of board members and the two concurrent roles of the chairman and general manager They are positively and negatively related to audit risk [6].

3) *Correlation between the board of supervisors and the risk of material misstatement*

Li and Wang used the influence of full coefficient to find that the board of supervisors with statutory supervisory power plays a pivotal role in supervision during the special period of China's economic transition and corporate governance. Although the board of supervisors had some discordant voices during the supervision process, this shows that the company encountered obstacles in the process of governance, and it is not a problem in the system of the board of supervisors. Therefore, it is better to explain that the construction of the governance mechanism of the Board of Supervisors is very important [7]. Li's research also confirmed that the scale of the board of supervisors has a negative correlation with the risk of material misstatement. The larger the board of supervisors, the more financially experienced supervisors, the stronger their ability in earnings management and supervision of financial accounting [8].

2.2 Auditors' Identification and Response to Potential Risks of Different Corporate Governance

The auditor's identification of potential risks to different corporate governance will be reflected in the auditor's behavioral changes, such as the level of fees, audit opinions, and the impact on audit quality.

1) *Auditors identify the impact of corporate governance on audit opinions*

For the study of the relationship between corporate governance and audit opinion, foreign countries started earlier. Shiminetal counts that about 15% of Chinese listed companies are registered between 1995 and 2000. The accountant issued a non-standard audit opinion. Through further research, the research results are obtained: the board of directors and the board of supervisors of Chinese listed companies have not played their due role in supervision, so the imperfect corporate governance will lead to the possibility of listed companies obtaining non-standard audit opinions [9]. Chinese scholar Zhang conducted empirical research on data from nearly ten years and found that corporate governance level is negatively correlated with audit opinion on continuing operations [10]. Liu and Hao selected the panel data of China's private listed companies from 2007 to 2011 as the original sample to study the correlation between corporate governance and audit opinions. The research results show that one of the important factors affecting the type of audit opinion is the quality of corporate governance reflected by the index, which means that companies with perfect corporate governance are more likely to be issued by the CPA as standard unqualified audit opinion types [11].

2) *Auditor identifies the impact of corporate governance on audit fees*

Foreign audit fees research involved corporate governance issues earlier, and Carcello found that board independence was significantly positively correlated with audit fees [12]. And then, Meng's research on the correlation between corporate governance institutions and audit fees helps to play the role of independent directors and strengthen the company's internal control. The results of the study indicate that the chairman and the general manager are closely related to the audit fees [13]. Through theoretical analysis and empirical test, Cui came to the following conclusions: there is a strong correlation between corporate governance and audit costs. A good corporate governance structure can reduce the audit costs of a company on the one hand and promote the positive impact of external audit on the company on the other hand [14].

2.3 Literature Review

According to the above literature, we can clearly obtain a lot of scholars from various regions at home and abroad to systematically study and analyze the relationship between the basic institutional structure of corporate governance and financial fraud from multiple perspectives. Since the angles and focus of the points are different, and the examples and research methods used are different, the above documents do not have the same conclusions or similar conclusions with similar laws. But in general, we can still find the relationship and conclusion we originally hoped for, that is, there is still a fairly obvious relationship between the basic institutional structure of corporate governance and fiscal fraud. It is precisely because of the universal existence of such associations that the research perspective of this paper is correct. In other words, the existence of research surface problems and the defects of its fundamental system are the basic ways and important angles to solve related problems. However, after reading the relevant literature, it is not difficult to find that the data and related information mentioned in these documents generally have relatively old conditions, most of which are based on the data of ten years ago, a small amount of nearly ten years and The proportion of data in the past five years is negligible. In the past ten years, especially in the past five years, no matter the market situation, the domestic and international financial environment has undergone tremendous changes and progress, including the government and related institutions, and even related companies and enterprises. A lot of efforts and changes have been made to ensure the stability of the economic and financial industry. The entire market environment tends to be optimized and improved, and major error prevention mechanisms have been established in all aspects. With the continuous reform and development of the economic system, companies and enterprises now ensure that their own economic and financial governance has become an important check of routines. Taking these new changes and situations into consideration, it is more practical to select newer data and samples to study relevant issues and propose relevant policy and institutional improvements, as well as the necessary guarantees for existing systems and situations.

3 Empirical Research

3.1 Related Research and Research Hypotheses

1) *Corporate Governance and Major Misstatement Risk Correlation Hypothesis*

Through the previous literature review part of the research on the relationship between corporate governance and auditing material misstatement risk, many scholars at home and abroad have theoretical and empirical analysis of the governance structure characteristics of Chinese listed companies, most of which are analyzed from the perspective of corporate governance efficiency. In the study of the governance characteristics of listed companies and corporate performance or corporate performance, its analysis of corporate governance characteristics also provides a reference for this article. However, on a holistic level, the quality of a company's governance will affect the company's earnings management, the transparency of financial information and the performance of management's performance, and then determine the company's overall audit of the company's overall misstatement the level of risk. The focus of this paper focuses on the relationship between corporate governance and the risk of material misstatement of audits, and therefore proposes:

Hypothesis 1: Corporate governance is a factor that significantly affects the risk of material misstatement, and companies with good corporate governance are more likely to reduce the risk of material misstatement.

2) *Correlation between corporate governance and auditor identification and response*

By identifying and judging a company's governance status, the auditor assesses the level of the company's material misstatement risk, and the assessment of its major risk misstatement level directly affects the auditor's audit behavior. For example, when the auditor recognizes that the board of directors and the board of supervisors have not played the proper supervisory role, such imperfect corporate governance will lead to increased likelihood of the company obtaining non-standard audit opinions and increased audit fees. Conversely, a good corporate governance situation will make auditors tend to issue standard unqualified opinions or reduce audit fees. In summary, the proposed:

Hypothesis 2: Corporate governance status is an important factor affecting the auditor's risk of material misstatement.

3.2 Sample Selection and Source

According to China's new "China Auditing Standards for Certified Public Accountants", the risk of material misstatement refers to the possibility of significant misstatement of the financial statements before the audit. As a result, the company's data for the three years of 2015–2017 has been collected. The selection criteria for these companies are: companies listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange, and those who have been punished by the Securities and Futures Commission for financial reporting fraud or violations. Eliminate financial listed companies, ST listed companies and projects with incomplete data.

3.3 Model Construction and Variable Design

Based on the empirical hypotheses and variables described above, two regression models were established to verify the two hypotheses.

Model 1 was designed through the study of the risk of material misstatement and its relationship with corporate governance related variables. Since the dependent variable only takes 1 or 0, choose Logistic.

Regression model for analysis:

$$FRAUD = \beta_0 + \beta_1 TOP1 + \beta_2 NOD + \beta_3 SUPERVIS + \beta_4 SIZE + \beta_5 ROE + \beta_6 DEBT + \varepsilon \quad (1)$$

Table 1 Variable definition

Variable category	Variable name	Variable meaning
Explained variable	FRAUD	Measured risk of material misstatement: FRAUD = 1 when the violation occurs, indicating that the risk of material misstatement is large, FRAUD is 0, and the risk of material misstatement is small
	LNFEE	The natural logarithm of audit fees
Explanatory variables	TOP1	The shareholding ratio of the largest shareholder (equity concentration)
	NOD	Listed company board size
	SUPERVIS	Number of supervisors of listed companies
Control variable	SIZE	Company Size
	ROE	Rate of Return on Common Stockholders' Equity
	DEBT	Gearing ratio

Interpreted variable: Fraud is a measure of the risk of material misstatement. When the company violates the rules and is punished by the CSRC, it is 1; otherwise it is 0. β_1–β_6 represents the coefficient of each variable, and ε represents the residual term (Table 1).

Model 2 In view of the above research on audit fees and corporate governance, Model 2 was designed for regression analysis:

$$LNFEE = \beta 0 + \beta 1TOP1 + \beta 2NOD + \beta 3SAME + \beta 4SIZE + \beta 5ROE + \beta 6DEBT + \varepsilon \quad (2)$$

Interpreted variable: The natural logarithm of the audit fee, LNFEE, is interpreted as a variable. β_1–β_6 represents the coefficient of each variable, and ε represents the residual term.

3.4 *Outcome of Practice*

1) *Descriptive statistical analysis*

In order to conduct a preliminary analysis of the selected samples, I conducted a descriptive statistical analysis of the samples. The subscript for the permeability of vacuum 0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o" (Table 2).

From the descriptive statistical analysis of the variables by the table, the following conclusions can be drawn:

The minimum value of the natural logarithm of the audit fees to be paid by the listed company is 12.42922, the maximum value is 15.91964, the average value is 13.7698765, and the standard deviation is 0.52006544; indicating that there is a large gap between the audit fees paid by different companies.

Table 2 Descriptive statistical analysis

Variable name	Number	Minimum	Maximum
FRAUD	258	0	1
Lnfee	258	12.42922	15.91964
TOP1 (%)	258	10.73100	100.00000
NOD	258	5.00000	12.00000
SUPERVIS	258	2	9
SAME	258	0.00000	1.00000
SIZE	258	19.01607	24.67661
ROE (%)	258	−46.19419	82.13298
DEBT	258	0.03402	1.27961
Valid N (listwise)	258		

The minimum shareholding ratio of the largest shareholder is 10.73100%, the maximum value is 100%, and the average value is 33.9167081%, which indicates that from the current stage, the concentration of ownership of Chinese companies is higher, and the standard deviation is 25.14973614. It also shows that the difference in the concentration of equity in Chinese companies is also obvious.

The minimum number of board members is 5, the maximum is 12, and the average is 8 people. The total number of people is in line with the number of people stipulated by the company law. It can also be seen that 8 people are the number of boards that Chinese companies are more willing to choose.

The minimum number of supervisory committees is 2, the maximum is 9 and the average is 3.56 or 4, indicating that the number of supervisors who are willing to choose in China is 4.

The situation of the chairman and the general manager accounted for 13.31008% of the total sample. The independence of the two concurrent companies will be restricted, but it also shows that most of the companies in China maintain the independence of the board (Table 3).

2) *Correlation coefficient analysis*

Correlation analysis can be used to analyze whether the two variables have a correlation, and whether the relationship between them can be positive or negative by positive and negative signs, but there is a defect that only the relationship between the two can be discussed and cannot be distinguished. Independent and dependent variables. From this, it can be initially analyzed that the risk of material misstatement has a positive correlation with the shareholding of the largest shareholder, and has a negative correlation with the number of board members and the number of supervisory boards. The natural logarithm of audit fees and the shareholding ratio of the largest shareholder, the number of board members and the dual roles are significant at the level of 0.01 (Table 4).

Table 3 Pearson correlation coefficient table

	FRAUD	Ln fee	TOP1	NOD	SUPERVIS	SAME	SIZE	ROE	DEBT
FRAUD	1	−.328**	.346**	−.386**	−.212**	−.223**	−.294**	0.048	−0.073
Lnfee		1	−.347**	.469**	.141*	.405**	.704**	−0.018	.215**
TOP1			1	−.210	.075	−.138*	−.389**	0.029	0.009
NOD				1	.226	.293**	.408**	0	0.072
SUPERVIS					1	0.073	−0.073	0.032	0.102
SAME						1	.361**	−0.019	.198**
SIZE							1	−0.024	.284**
ROE								1	−.123*
DEBT									1

a.** indicates significant correlation at the 0.01 level (both sides)
b.* indicates a significant correlation at the 0.05 level (both sides)

Table 4 Model 1 logistic regression test results (Dependent variable: FRAUD)

	B	S.E.	Wald	df	Sig.	Exp(B)
TOP1	.029	.007	16.296	1	.000	1.029
NOD	−.405	.125	10.476	1	.001	.667
SUPERVIS	−.529	.186	8.033	1	.005	.589
SIZE	−.223	.209	1.135	1	.287	.800
ROE	−.442	.884	.250	1	.617	1.555
DEBT	.098	.802	.015	1	.903	.907
Constant	7.007	4.356	2.588	1	.108	1104.348

3) *Regression analysis*

According to the regression results of model one, it can be concluded that:

The higher the shareholding ratio of the largest shareholder, the greater the risk of material misstatement, that is, the shareholding ratio of the largest shareholder is positively related to the risk of material misstatement, because the shareholding ratio of the largest shareholder is a substitute for equity concentration. Variables, therefore, the more concentrated the equity, the greater the risk of material misstatement, and their relationship is significantly positively correlated according to sig. The greater the number of board members, the smaller the risk of material misstatement, that is, the size of the board of directors is negatively correlated with the risk of material misstatement, and based on sig 0.001, their relationship is significantly negatively correlated. The larger the size of the board of supervisors, the smaller the risk of material misstatement, that is, the proportion of shares held by the largest shareholder is negatively correlated with the risk of material misstatement, and their relationship is significantly negatively correlated according to sig of 0.005 (Table 5).

Among the control variables, the total assets and the return on net assets are negatively correlated with the risk of material misstatement. The asset-liability ratio

Table 5 Model 2 multiple linear regression results

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.901	.578		11.940	.000
	TOP1	−.002	.001	−.078	−1.687	.093
	NOD	−.070	.017	.190	4.043	.000
	SAME	.245	.081	.140	3.034	.003
	SIZE	.283	.028	.540	10.242	.000
	ROE	.000	.008	.003	.063	.950
	DEBT	.053	.110	.022	.479	.632

is positively correlated with the risk of material misstatement, but it is not significant. The reason may be that the selection of sample data is closely related, and the sample size is not large enough, and it is also closely related to the business environment due to the influence of the relevant industry in which the company is located.

According to the regression results of Model 2, it can be concluded that:

The higher the shareholding ratio of the first largest shareholder, the smaller the natural logarithm of the audit fee, that is, the shareholding ratio of the largest shareholder is negatively correlated with the audit expense, because the shareholding ratio of the largest shareholder is a substitute for the concentration of equity. Variables, therefore, the more concentrated the equity, the less audit fees the company spends, but because the value of sig is equal to 0.093, their correlation is not significant. The greater the number of board members, the smaller the natural logarithm of audit fees, that is, the size of the board of directors is negatively correlated with the audit fees, and their relationship is significantly negatively correlated according to sig 0. When the chairman and the general manager are concurrently employed, the audit fee is higher, that is, the two concurrent positions are positively related to the audit fee, and their relationship is significantly positively correlated according to sig of 0.003.

Among the control variables, the total assets are significantly positively correlated with the audit fees. The return on net assets and the asset-liability ratio are positively correlated with the audit fees, but not significant. The reason may be that the selection of sample data is closely related, and the sample size is not large enough, and it is also closely related to the business environment due to the influence of the relevant industry in which the company is located.

4) *Robustness test*

The robustness test is conducted to test whether the empirical test results obtained above are stable, that is, when we change the parameters used in the empirical test, we observe whether the results of the empirical test will change significantly. If the positive or negative correlation or significance of the empirical test changes greatly with the change of parameters, then the result of the empirical test can be concluded to be unstable. Conversely, the stability of the empirical test can also be confirmed.

The test of robustness can be started from aspects: adjust the data classification. Perform variable substitution. Change the measurement method.

Based on the actual situation, this paper starts from the data to test the robustness of the empirical results. The ratio of the number of shares outstanding to replace the shareholding ratio of the largest shareholder indicates the equity result, and the proportion of independent directors replaces the size of the board of directors as a substitute for the structure of the board of directors. The test results are shown in the table below.

The results in the above table indicate that the proportion of outstanding shares is significantly negatively correlated with the risk of material misstatement of audits. The higher the proportion of shares outstanding and the lower the shareholding ratio of the largest shareholder, the lower the concentration of equity, and the better ownership structure is the performance of corporate governance, the lower the risk of material misstatement. As with the scale of the board of directors in the evidence, the proportion of independent directors in the board of directors is also negatively related to the risk of material misstatement. In summary, using different variables can be concluded that corporate governance is a factor that significantly affects the risk of material misstatement, and companies with good corporate governance are more likely to reduce the risk of material misstatement (Tables 6 and 7).

Table 6 Model 1 robustness test

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	TRADABLE	−3.630	.865	17.594	1	.000	.027
	IDRATE	−3.189	3.502	.829	1	.362	.041
	SUPERVIS	−17.795	2461.916	.000	1	.994	.000
	SIZE	−.477	.239	3.970	1	.046	.621
	ROE	.377	1.013	.139	1	.710	1.458
	DEBT	−.749	.923	.659	1	.417	.473
	Constant	67.742	7385.751	.000	1	.993	2.629E29

Table 7 Model 2 robustness test

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	*Std. Error*	*Beta*		
1	(Constant)	14.611	.601		24.330	.000
	TRADABLE	−.812	.111	−.396	−7.287	.000
	IDRATE	−1.672	.452	−.182	−3.702	.000
	SAME	.902	.086	.511	10.501	.003
	SIZE	−.018	.030	−.034	−.599	.550
	ROE	−.002	.008	−.008	−.178	.859
	DEBT	−.075	.124	−.030	−.602	.548

The conclusions in the above table indicate that there is a significant negative correlation between the variables after replacement, the proportion of outstanding shares and the proportion of independent directors and audit fees. The high proportion of tradable shares and the high proportion of independent directors respectively represent the dispersion of equity and better structure of the board of directors, which is a good performance of corporate governance, and the corresponding audit fees are low. This draws the same conclusion as the original model, indicating that the model is robust.

4 Research Conclusions and Recommendations

4.1 Analysis Conclusion

This article takes a sample of companies listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange in 2015–2017.

Taking the company's total assets and profit indicators as control, the company's governance status is represented by the ownership structure, board structure and supervisory board structure. The relationship between corporate governance and auditing major risk misreporting is studied separately and the auditor's response.

According to the model 1 Logistic regression results, the following conclusions can be drawn:

1) There is a positive correlation between the concentration of equity and the risk of material misstatement of the audit. The shareholding ratio of the largest shareholder is also high, and the risk of major misstatement of audits is higher. According to the results of descriptive statistics, it is known that the concentration of ownership of Chinese enterprises is relatively high. Under this circumstance, the majority shareholder has strong control over the enterprise. On the one hand, major shareholders may use their shareholding advantage to "sell" the company, and as the controlling shareholder of the company, they may use this advantage to squeeze or even harm the interests of minority shareholders; on the other hand, the more concentrated the equity The more likely it is to breed and cover up fraud, when the major shareholder has fraud, it may manipulate the management, intervene in the implementation of internal control, and use information asymmetry in the audit of certified public accountants, not to disclose true information to the CPA, Due to the inherent limitations of auditing, CPAs will find it more difficult to obtain adequate and appropriate audit evidence, which in turn will affect the CPA's proper audit opinion.
2) The size of the board of directors is negatively correlated with the risk of material misstatement of the audit. The greater the number of board members, the lower the risk of major misstatement of audits. For the relationship between the two, there have been two very different conclusions in previous academic research. I believe that this trend is determined by the status quo of Chinese enterprises.

According to the descriptive statistics, the average number of board of directors of Chinese enterprises is 8 people. There is no limit to the number of board members, and there will be no "free rider" phenomenon. However, expanding the size of the board of directors within a reasonable range will help strengthen the board's job competency and enable more investors to participate in the governance of the company, effectively avoiding the manipulation of the company by a few major shareholders and causing fraud; In this case, the company can also hire more independent directors to help the company better supervise the management and effectively control the risk of major misstatement of the audit.

3) The size of the board of supervisors is negatively correlated with the risk of material misstatement of the audit. The greater the number of supervisory boards, the lower the risk of major misstatement of audits. As with the size of the board of directors, there have been two very different conclusions in the past academic research on the relationship between the two. I believe that this trend is determined by the status quo of Chinese enterprises. According to the descriptive statistics, the average number of supervisory boards of Chinese enterprises is 3.56, that is, less than four, far less than the limit of the number of supervisory committees. The size of the board of supervisors is an important factor limiting the effectiveness of the board of supervisors. The larger board of supervisors will help the board of supervisors to play its work and help companies reduce the risk of material misstatement.

In summary, corporate governance is a factor that significantly affects the risk of material misstatement. Among them, good corporate governance, including the reduction of equity concentration, the size of the board of directors and the expansion of the size of the board of supervisors, help companies reduce the risk of material misstatement.

According to the model 2 multiple regression results, the following conclusions can be drawn:

1) The relationship between the shareholding ratio of the first largest shareholder and the audit fee is not significant. Originally speaking, the higher the shareholding ratio of the largest shareholder, the more concentrated the shareholding structure, and the greater shareholder is more motivated to supervise the work of the company's management, thus reducing audit fees. Or the proportion of the largest shareholder is too high, so that the management's behavior can be manipulated, resulting in fraud, and thus tend to spend less money on company audits. However, this result may indicate that the auditor's response to changes in corporate governance status, that is, when corporate governance is poor, increases audit fees.
2) The scale of the board of directors is negatively related to the audit fees. To a certain extent, the size of the board of directors is a substitute for corporate governance. That is, when the size of the board of directors is larger, it helps to enhance the exercise effect of the board of directors and reduce the occurrence of fraud, so that the state of corporate governance is improved, and the governance

of the company is more Well, the lower the risk misstatement assessed by the CPA auditor, the lower the audit fee.

3) The two roles of chairman and general manager are positively related to audit fees. It shows that when the two positions are combined, the independence of the board of directors is even worse, which lowers the level of corporate governance. The lower the risk of misstatement of the major risks assessed by the CPA auditor, the lower the audit cost. It can be seen that separating the chairman from the general manager can improve corporate governance and thus reduce audit fees.

4.2 Policy Suggestion

1) *Optimizing the shareholding structure*

Through the research in this paper, we can find that the excessive concentration of equity is not conducive to the improvement of corporate governance, and the current situation of high concentration of equity in China, I think we can reduce the concentration of ownership to a certain extent, and try to avoid a monopoly situation. The relatively diversified ownership structure is conducive to mutual restraint of multiple parties, exerting the enthusiasm of multiple stakeholders, making effective decisions on the company's operations, thereby improving corporate governance, and also helping auditors reduce audit fees when auditing.

2) *Taking into account the size and independence of the board of directors*

According to the theory of management, the size of the board of directors will reduce its exercise effect. However, after the descriptive statistics and empirical research of the text, according to the current situation of China, the board of directors is small in scale and the concentration of ownership is high, and it is still necessary to expand the scale of the board of directors. In the hope that the board of directors will play a better role and restrict the shareholders with a large shareholding. Therefore, properly increasing the size of the board of directors is one of the ways to optimize corporate governance.

The two powers of the chairman and the general manager reflect the independence of the board of directors. Separating these two positions helps each of them to play a better role and enhance the independence of the board. Therefore, when considering corporate governance, two should be Only set up separately.

3) *Strengthen the effectiveness of the board of supervisors*

The focus of the governance of the Board of Supervisors is mainly reflected in two aspects. One is whether the Board of Supervisors can adhere to professional ethics in the course of auditing, and adhere to the principles of fairness, independence, objectivity and efficiency. In addition, as for the issue of staff deployment within the Board of Supervisors, since the size of the Board of Supervisors obviously affects the risk of material misstatement of listed companies, in order to make the supervision more effective, it is necessary to plan personnel structure and personnel deployment.

Make certain considerations for deployment. The most realistic option at present is to improve the structural characteristics of the supervisory board. The specific contents include: the nomination of supervisors should be standardized, and a fixed system or enforcement mechanism should be formed, and the voting method of cumulative addition and multiplication should be adopted. The shareholding ratio of shareholders cannot be used as a reference for voting, but should be multiplied by the number of shares held by the number of supervisors to be elected. In this way, when voting for elections, it is possible to give small and medium-sized shareholders a great choice. They can concentrate their voting rights and give them targeted candidates for supervisors, which may be a supervisor or several supervisors. This kind of voting method does not use equity as the main reference, which weakens the discourse power of major shareholders to a certain extent. The main beneficiaries must be small and medium shareholders. As a result, voting is more representative of the public, making the company's decision making more comprehensive.

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The Relationship Between the Human Settlement and Economic Development in Hangzhou

Pengyan Li, Hao Peng, and Sai Tang

Abstract Through the establishment of specific indicators of Hangzhou's human settlements environment and economic development from 2000 to 2016, this paper explores the contribution degree of each principal component to the indicators and the changes of the comprehensive index in 17 years. Then, in order to analyze the specific relationship between the two development, the VAR model of the two is constructed. Through co-integration analysis, Granger causality analysis and regression analysis, the deep internal relationship between Hangzhou's human settlements environment and economic development is finally obtained. The results show that the economic development of Hangzhou is not the reason for the improvement of the environment of the human settlements, and the improvement of environment of the human settlements can promote the economic development, and there is a time lag. In view of this causality, it is suggested that attention to the environment of the human settlements should not be neglected while the economy is developing rapidly. Attention to the improvement of the human settlements environment conditions can play a long-term role in promoting economic development.

Keywords Human settlement environment · Economic development · Principal component analysis · VAR model

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1 Introduction

The term "human settlement" refers to geographical location and the basic conditions necessary for people to live a life. The quality of a human settlement also serves as an important marker of regional economic development within a country. Finally, the quality of a human settlement is also a measure of material and cultural standards. The development of any country or region cannot be left to chance. Hangzhou, the newest first-tier Chinese city (one of five), provides an interesting test case. From 2000–2016, its per ca-pita GDP rose from 0.02 million RMB to 0.12 million RMB. The economy has developed rapidly. However, the rapid development of the city's economy and the process of urbanization has caused a sharp increase in population, resulting in a large increase in air pollution caused by exhaust fumes and industrial discharge, and water pollution arising from an increase in waste water. All these problems have resulted in a severe ecological imbalance, worsening the quality of life for residents. Hence, researching the relationship between the human settlement of Hangzhou and the development of the Hangzhou economy is significant for analyzing the comprehensive development situation in order to determine the proper balance between development and a city's ecological health.

To date, most research, both international and domestic, about this issue concerns two primary areas: either human settlement, or the relationship between human settlement and economic development. The first mention of the concept of human settlement occurred in 1898 by the British social reformer Howard, who developed "pastoral city theory," which attempted to solve the problems caused by the Industrial Revolution. Howard sought to maximize the advantages of urban-rural integration to control the city's population growth to increase the quality of human settlements [1]. In the 1950s, a Greek architect and city planner C.A. Doxiadis coined the term "ekistics" to define the science of human settlements. He described five main components of human settlements: people, society, nature, architecture, and interconnection. He emphasized that people need to research human settlements systematically and comprehensively from multiple standpoints including society, technology, culture, education, medicine and health, and so on. His work marked the emergence of the science of human settlements [2]. In China, this concept gained traction in the 1980s. Professor Wu set up the basic framework of research in Chinese human settlements. Subsequent research in Chinese human settlements is based on his theory [3]. By a multivariate statistical analysis, they explored the quality-of-life environments of the first set of villages constructed in the municipal area surrounding Beijing, paying particular attention to the physical characteristics, influence level, and development status in these formerly rural areas, which became Beijing suburbs [3]. Liu used a quantitative analysis of ten years of data [4], Liu conducted a study on the livability of human settlements in Kunming and discussed the issue of the harmonious development of human settlements, the economy, and culture [4]. Yan et al. analyzed the situation of human settlements in different provinces of China, and proposed the classification and guidance of environmental issues in different provinces [5].

On the other hand, the study of the relationship between human settlements and economic development is also a multifaceted endeavor. In earlier studies, Rees argued that although human technological progress and economic achievements are enormous, they are still inseparable from the support of natural ecosystems [6]. American economist Simon Smith Kuznets conducted an in-depth study of the relationship between economic growth and regional environmental pollution in 66 different countries and regions, highlighting the environmental pollution status of these countries and regions. His results show that initially, economic improvement as measured by per ca-pita national income occurs concomitantly with degradation of environmental quality, but after a time, pollution stabilizes or decreases while national income continues to increase. That is, there is an inverted U-shaped relationship between the degree of environmental pollution and economic growth over time. Based on this empirical study, Krugman et al. summarized the inverted U-shaped relationship between the amount of environmental pollution and economic growth as the environmental Kuznets curve hypothesis [7]. Subsequently, other scholars focused on the link between economic development and protection of the environment. For example, Richard and Christopher studied the possible relationship between economic growth and environmental protection. For the long-term development of the city, they felt it necessary to achieve both aims, which they termed coordinated development [8]. In China, the study of related issues is mainly based on cities or regions within China itself. Xiong used uncertainty analysis to study the relationship between human settlements and economic development in Changsha. Deng, Zhang, and Li used Lanzhou City as an example, employed empirical analysis to construct a set of indices that included 40 separate factors to systematically evaluate the coordination of environmental and economic development [9]. Shan et al. analyzed the coordination of environmental quality and economic development in Zaozhuang, In the same year, Xi'an and Taiyuan put forward countermeasures for each city's environmental preservation and economic development [10–12].

Hangzhou is a very good example of a blend of tradition and modernity, economy and culture. In recent years, a new economic model has developed rapidly in this city, and people's happiness index has been continuously improving. Therefore, taking this as an example to study the relationship between human settlements and economic development has the significance of indicators-first, rich and long history. Hangzhou has a history of more than 2,200 years since it was established in the Qin Dynasty. It is also one of the birthplaces of Chinese Civilization and ranks among the seven ancient capitals in China. The 13th-century Italian traveler Marco Polo marveled at Hangzhou, calling it "the most graceful and splendid city in the world." Second, excellent location. Hangzhou is the provincial capital of Zhejiang Province and its center of economy, culture, science and education; it is the central city of the Yangtze River Delta, and it ranks among the first batch of national historical and cultural cities. Hangzhou benefits from the convenience of the Beijing-Hangzhou Grand Canal and the Tongshang Port, as well as from its well-developed silk and grain industry, and was historically an important commercial distribution center for those products. Later, the opening of railway lines such as the Shanghai-Hangzhou Railway and Shanghai's import and export trade enabled the light industry to develop rapidly. Third, high-speed economic development. In 2017, Hangzhou's per ca-pita GDP reached 1,255.6 billion yuan, an increase of 8% from 2016. Urban and rural resident per ca-pita disposable income reached 56,276 yuan and 30,397 respectively, an increase of 7.8 and 8.9% over the previous year. At the end of the year, the balance of household deposits reached 867.1 billion yuan, calculated according to the annual resident population, and the per ca-pita deposit was 92,957 yuan. The service sector as a proportion of GDP rose to 62.6%, which is higher than the average level of the whole country.

Because of its abundant natural resources, and rapid economic and cultural improvement, this article uses Hangzhou as an example of intentional development. Using indicators that are people-oriented, comprehensive, unique to this setting, and both theoretically sound and practically implementable, and considering the specific human situation and economic development in Hangzhou, this paper evaluates economic development in Hangzhou in terms of human factors and concerns such as environmental quality, cultural opportunities, and the quality of public interactions.

2 Indicator Construction and Data Processing

2.1 Indicator Construction

Following the principles outlined above, a total of 30 relevant indicators related to Hangzhou were selected, including 16 indicators of human settlements and 14 indicators of economic development. These indicators were obtained from the Hangzhou Statistical Yearbook.

1) *Economic development indicators:* In terms of human settlements, combined with the actual situation in Hangzhou, the four aspects of living conditions, environmental greening, infrastructure and education and health are stratified with the following indicators: per ca-pita living area; population density; per ca-pita pork, beef and mutton production; per ca-pita vegetable production; green coverage in otherwise built-up areas; per ca-pita public green space; waste-water discharge compliance rates; comprehensive utilization of solid waste; paved road area per 10,000 people; public transport vehicles per 10,000 people; annual electricity consumption per capital; annual per ca-pita 16 indicators of daily water consumption; the number of full-time teachers per 10,000 people;, the number of students per 10,000 in higher education institutions; the number of doctors per 10,000 people; and the number of hospital beds per 10,000 people are used as indicators to construct the evaluation of human settlements in Hangzhou.
2) *Economic development indicators:* For the indicators of the economic development level in Hangzhou, five aspects including economic strength, economic vitality, industrial structure, economic extroversion and household income consumption were selected as the classification layer. The specific indicators measured were: per ca-pita GDP; per ca-pita industrial output value; per ca-pita

local fiscal revenue; GDP growth rate; investment per ca-pita in fixed assets investment; share of GDP accounted for by secondary industry; share of GDP accounted for by tertiary industry; per ca-pita actual use of foreign capital; per ca-pita import and export; average employee wages; per ca-pita disposable income; per ca-pita year-end savings deposit balance; residents' consumer price index; and total retail sales per day are used to construct the evaluation index.

System for economic development in Hangzhou, as shown in Table 2.

2.2 Data Processing

Because the indicators selected for use in this study are measured in different units, the data first had to be standardized. Then, a principal component analysis of the standardized data was used to obtain the total variance of the human settlement system, the total variance of the economic development system, and the Human settlement of Hangzhou. The composition matrix and the matrix of economic development components of Hangzhou can be got.

The first main component of the human settlement system concerns environmental factors, which is divided into three sub-components. The first sub-component of environmental factors is represented by the variable *F1*, which represents the greening and traffic conditions of Hangzhou. The indicators comprising this variable *F1*, namely: the green coverage rate of the built-up area (*A5*); the per ca-pita possession of the public green area (*A6*); and the paved road area per 10,000 people (*A9*); and the proportion of indicators such as buses (*A10*) per 10,000 people is large. The green coverage rate (*A5*) of the built-up area and the public green area (*A6*) per capita can be attributed to green conditions, and the paved road area per 10,000 people (*A9*) and the bus (*A10*) per 10,000 people can be regarded as traffic conditions.

Similarly, the second principal sub-component and the third principal sub-component of the human settlement environment in Hangzhou can be regarded as variable *F2* and variable *F3*, respectively. Among the indicators comprising variable *F2*, the number of full-time teachers per 10,000 people (*A13*) and the number of students enrolled per 10,000 people in higher education institutions (*A14*) account for a large proportion, so that the variable *F2* can represent Hangzhou. Educational conditions; among the indicators comprising variable *F3*, the number of doctors per 10,000 people (*A15*) and the number of medical beds per 10,000 people (*A16*) account for a large proportion, and *F3* can be considered as the medical condition of Hangzhou.

Similarly, the first and second principal components of Hangzhou's economic development are set to variables *E1* and *E2*, respectively. Among the indicators constituting the variable *E1*, the per ca-pita GDP (*B1*), the per capita local fiscal revenue (*B3*), the per capita disposable income (*B11*), and the per capita year-end savings deposit balance (*B12*) account for a large proportion. These indicators are the embodiment of Hangzhou's economic strength, so the variable *E1* represents the

Table 1 Numerical values and composite indices of principal components

	Human settlements				Economic development		
	F1	*F2*	*F3*	*F*	*E1*	*E2*	*E*
2000	−17.58	−5.53	−0.62	−14.15	−16.23	−0.66	−14.94
2001	−15.48	−3.08	0.13	−12.11	−15.35	−1.28	−14.18
2002	−13.64	−0.75	0.82	−10.28	−14.77	−1.46	−13.66
2003	−11.20	0.97	1.21	−8.13	−13.69	−0.67	−12.61
2004	−8.66	1.48	1.36	−6.13	−11.22	0.99	−10.20
2005	−7.42	3.13	1.27	−4.93	−7.97	0.41	−7.28
2006	−2.13	4.86	0.97	−0.71	−5.77	0.60	−5.24
2007	−0.51	1.96	−1.46	−0.18	−4.48	1.56	−3.98
2008	−0.45	1.87	−1.23	−0.13	−0.36	1.89	−0.17
2009	1.52	1.88	−1.70	1.31	0.63	−1.51	0.45
2010	2.77	0.01	−2.07	1.90	3.14	1.24	2.98
2011	5.64	−0.56	−1.19	4.03	7.53	1.58	7.04
2012	8.08	−0.62	−0.62	5.90	10.09	0.14	9.26
2013	10.12	−0.83	−0.30	7.42	13.08	−0.28	11.96
2014	14.30	−0.78	0.19	10.61	15.54	−0.59	14.19
2015	15.53	−1.63	1.03	11.46	18.21	−0.94	16.62
2016	19.11	−2.39	2.22	14.12	21.63	−1.01	19.74

economic strength of Hangzhou; the consumer price index (*B13*) accounts for the largest and concentrated proportion of the indicators that constitute the variable *E2*, and this indicator reflects the economic operating environment of Hangzhou, so *E2* represents the economic operating environment of Hangzhou.

Finally, values of the main components of the human settlement environment and economic development in Hangzhou and the comprehensive evaluation index of the two are shown in Table 1.

3 Model Construction and Analysis

3.1 Model Building

In order to understand the complex relationship between phenomena, a vector autoregressive model, which is an unstructured model that reflects the varying rate of change of different indicators (a stochastic process model used to capture the linear interdependencies among multiple time series), was chosen as a research tool. The expression of the model is usually written as:

$$Y_t = \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \beta_0 X_t + \ldots + \beta_r X_{t-r} + e_t \tag{1}$$

Where *Xt* is an exogenous variable, *Yt* is an endogenous variable, $\alpha_1 \ldots . \alpha_p$ and $\beta_0 \ldots \beta_r$ are the matrix of coefficients to be estimated, and e_t is a random interference term (there is no autocorrelation). Since it is necessary to ensure that the sequence is stable before establishing the vector autoregressive model, the existing data was checked and processed.

3.2 ADF Unit Root Test and Co-integration Test

Based on the empirical study of time series data, if the data is not stable, the phenomenon of "pseudo-regression" will appear, making the statistical tests meaningless. Therefore, the unit root test needs to be performed first. According to the comprehensive economic development index of Hangzhou has shown a rising trend, but the human settlements index has shown a trend of rapid growth and steady growth. Therefore, in the co-integration analysis, it is necessary to test each part of the data separately. The three parts of the data, namely 2000–2006, 2007–2016 and 2000–2016, were tested to determine whether the data can be considered to be in a stable situation (Table 2). It was found that the initial sequence from 2000 to 2006 was stable, and the 2007–2016 sequence did not pass the stationarity test. The data from 2000 to 2016 was also stabilized after the first-order difference. Linear regression of the data from 2000 to 2006 yields the following regression equation:

$$RJHJ = 5.2 + 1.19JJFZ \tag{2}$$

Linear regression was performed on the first-order difference of the data from 2000 to 2016, and the following regression equation was obtained:

$$RJHJ = 0.001 + 0.72JJFZ \tag{3}$$

Table 2 Results of unit root test for human settlements and economic development in Hangzhou

Year	Index	ADF value	5% significant level	10% significant level	Stability
2000–2006	RJHJ	−244.63	−5.34	−4.19	Yes
	JJFZ	−6.51	−5.34	−4.19	Yes
2007–2016	RJHJ	−2.28	−4.25	−3.59	No
	JJFZ	−5.23	−4.25	−3.59	Yes
2000–2016	RJHJ	−2.24	−3.73	−3.31	No
	D(RJHJ)	−4.44	−3.76	−3.33	Yes
	JJFZ	−2.81	−3.73	−3.31	No
	D(JJFZ)	−3.66	−3.79	−3.34	Yes

Table 3 Unit root test results of residual sequence E

Year	ADF value	5% significant level	10% significant level	Co-integration
2000–2006	−4.75	−4.11	−3.52	Yes
2000–2016	−4.47	−3.76	−3.33	Yes

Since the two sets of data passed the stationarity test, their residual sequence was tested. The test results are shown in Table 3. The results show that there is a co-integration relationship between the two sets of data.

3.3 Granger Causality Test

The Granger causality test was mainly used to analyze the causal relationship between the Human settlement and economic development in Hangzhou. Since there was no co-integration relationship between Human settlement and economic development in Hangzhou from 2007–2016, there is no need to analyze causality. According to the test results, after two periods of lag, there is no causal relationship between them. When the three periods lag, the Human settlement becomes the cause of economic development. We can assert that this is more in line with what we know in life, that is, the improvement of Human settlements leads to simultaneous or future economic development, but it is obvious that economic development by itself is not the cause of improvement in Human settlements. The specific statistical results are shown in the table below.

3.4 Regression Analysis

Based on the test and analysis above, we can get the regression equation of human settlements environment and economic development. The regression equations with the Human settlement and economic development as the dependent variables are obtained.

$$RJHJ_{\mathrm{t}} = 1.48 - 0.16RJHJ_{\mathrm{t}-1} + 0.07RJHJ_{\mathrm{t}-2} + 0.35JJFZ_{\mathrm{t}-1} - 0.16JJFZ_{\mathrm{t}-2} \tag{4}$$

$$T(in\ order) : (1.50)(0.34)(0.34)(0.34)(0.32)$$

$$AIC = -3.505781 \qquad SC = -3.734016$$

Table 4 Granger causality test results

Lag length	Granger causality	F value	P value	Conclusion
1	JJFZ → RJHJ	0.93	0.35	Refuse
	RJHJ → JJFZ	1.06	0.32	Refuse
2	JJFZ → RJHJ	0.62	0.56	Refuse
	RJHJ → JJFZ	1.77	0.22	Refuse
3	JJFZ → RJHJ	0.39	0.76	Refuse
	RJHJ → JJFZ	28.38	0.00	No refuse

$$JJFZ_{\mathrm{t}} = 1.88 - 0.06JJFZ_{\mathrm{t-1}} + 0.12JJFZ_{\mathrm{t-2}} - 0.20\mathrm{RJHJ}_{\mathrm{t-1}} - 0.41RJHJ_{\mathrm{t-2}} \tag{5}$$

$$T(in\ order) : (1.19)(0.27)(0.25)(0.27)(0.27)$$

$$AIC = -3.306675 \qquad SC = -3.155383$$

Attached is the test result: Table 4.

By two regression equations can be found all the coefficients are not through the T-test (|T| less than 2), that between residential environment and economic development of Hangzhou in the next two years the close relationship did not influence each other, we this also verified the conclusion in the Granger causality test, namely in the short term within two years (lag) Hangzhou living environment improvement will not affect the economic development, economic development will not make the living environment is improved.

3.5 Equation Decomposition Analysis

Table 5 shows the results of the variance decomposition. From the left half, the effect of the new interest from (4) on the standard error fluctuations of RJHJ and JJFZ, we can see that although the contribution to RJHJ has decreased, it has remained above 90%. This shows that Hangzhou's economic development contributes less to the improvement of its Human settlement; the right half has reached different conclusions. The first and second phases of the new interest from (5) affect the JJFZ standard error fluctuation. The impact is small, but since the third period, this effect has increased significantly, and the contribution rate increased to around 30%. This analysis proves that the improvement of the Human settlement in Hangzhou has had an impact on its economic development, but there is a time lag, generally of three years or more.

Table 5 Results of variance decomposition

Period	Variance decomposition of human settlements			Variance decomposition of economic development		
	S.E.	*RJHJ*	*JJFZ*	*S.E.*	*RJHJ*	*JJFZ*
1	1.22	100	0	0.97	2.99	97.01
2	1.29	93.41	6.59	1.00	8.41	91.59
3	1.31	90.61	9.39	1.14	28.92	71.08
4	1.33	90.45	9.55	1.17	29.93	70.07
5	1.34	90.59	9.41	1.17	29.84	70.16
6	1.34	90.42	9.58	1.18	30.19	69.81
7	1.34	90.30	9.70	1.18	30.57	69.43
8	1.35	90.29	9.71	1.18	30.70	69.30
9	1.35	90.29	9.71	1.18	30.69	69.31
10	1.35	90.29	9.71	1.18	30.70	69.30

4 Conclusion and Policy

Firstly, the economy of Hangzhou City achieved rapid development from 2000–2016, but the development of the Human settlement first experienced rapid improvement, followed by stasis beginning in 2007. The Human settlement, as reflected by greening, transportation, education and medical conditions, and economic development, as represented by economic strength and economic operating environment, achieved coordinated development in the early years, but since 2007, there is no longer any coordination between the two. The environment has not kept pace with the economic development rate, and the improvement of the Human settlement has been neglected in the process of economic development. The harmonious development of the Human settlement and economy in Hangzhou over the past 17 years is thus imperiled.

Secondly, the improvement of the Human settlement will promote economic development. However, this effect is not immediate, and although it will not be seen for about three years, this impact will remain profound. Development is stimulating. In the process of economic development in Hangzhou, it is necessary to strengthen the city's ecological environment construction, infrastructure construction and public utility construction, improve the efficiency of life and work; develop a green economy, a circular economy and a cooperative economy, and give full play to the coordination between the development of the economy and the Human settlement.

Thirdly, it is not difficult to see that Hangzhou's economic development in recent years has benefited from the newly-formed business and globalization, such as the economic development model of online and offline integration and the development of cross-border e-commerce, which not only promoted economic development but also Hangzhou's human settlements improvement. Local governments and e-commerce companies are now working together to help people living in poverty-stricken areas to sell their products online and improve their quality of life.

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The Correlation Between Highway Transportation and Regional Economic Development in Inner Mongolia

Lichen Zeng

Abstract This paper analyzes the development of highway transportation in Inner Mongolia, comprehensively analyzes the correlation between highway transportation in Inner Mongolia and regional economic system by using research methods such as transportation economic elasticity analysis and gray correlation analysis, establishes a quantitative analysis model between economic development indicators and highway transportation development indicators in Inner Mongolia, points out the problems existing in the development of highway transportation in Inner Mongolia, and puts forward relevant policy suggestions.

Keywords Highway transportation · Economic development · Economic elasticity analysis of transportation

1 Introduction

With the rapid development of national economy and urbanization, highway transportation has become an important driving factor in regional economic development due to its advantages of wide coverage, relatively low construction cost and high transportation flexibility. Inner Mongolia is located in the north of China, adjacent to Mongolia in the north and bordering Russia in the northeast. It has unique geographical features and advantageous location in the communication area. Inner Mongolia is the key area of the "the belt and road initiative" strategy. It has the advantage of connecting Russia and Mongolia and is the window for China to open to the north. Highway transportation is the dominant mode of transportation in Inner Mongolia.

With the implementation of the national development strategy, Inner Mongolia's economic development momentum has increased and higher requirements have been put forward for the development of road transportation in Inner Mongolia. This paper

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discusses the relationship between highway transportation and economic development in Inner Mongolia by using research methods such as transportation economic elasticity analysis and gray correlation analysis, and provides policy suggestions for highway transportation development in Inner Mongolia.

2 Literature Review

The research on the correlation between transportation and regional economic development put forward by foreign researchers originated from the first half of the 19th century. Weber and other scholars regarded transportation as the prerequisite factor affecting the economy from the perspective of location. Adam Smith and others studied transportation and industrial layout. Rostow and other scholars have combined the unbalanced development of transportation and economy, demanding to realize the vigorous development of transportation.

Domestic scholars mainly study the impact of highway transportation on regional economy from the perspective of space and time. At the same time, some scholars study from different stages of traffic development and economic development. Among them, the main representative views are "alternate push-pull relation theory", "interaction theory" and "external effect theory" [1].

While carrying out qualitative research on the relationship between highway transportation and regional economic development, quantitative analysis is also carried out. Liu uses input-output method to analyze the impact of unit output value of transportation industry on national economic growth [2]. Chen and others adopted the data envelopment analysis method, and selected the total transportation routes, passenger transportation and turnover volume, and freight transportation and turnover volume as indexes, and concluded that the development degree of transportation and economic development are generally coordinated with each other [3]. Ding established the submodels of transportation, economy and the relationship between transportation and other industries to quantitatively analyze the non-linear relationship between transportation and economy, and proposed the concept of transportation reaction factor and its estimation equation [4].

Based on the summary of the research on the relationship between transportation and regional economy by Chinese scholars, it can be found that most of the research results on the relationship between transportation and economic development are from the macro perspective or from the perspective of transportation promoting economic development unilaterally. However, there is little research on the relationship between highway transportation and economic development in underdeveloped areas, especially in Inner Mongolia, which has great development potential.

3 The Present Situation and Existing Problems of Highway Traffic Development in Inner Mongolia

3.1 Current Situation of Highway Traffic Development in Inner Mongolia

According to the Inner Mongolia Statistical Yearbook, by the end of 2018, a total of 55.4 billion yuan had been invested in fixed assets for highway transportation, 16,000 km of highway construction had been started, 3,200 km of new highways had been added, and the total mileage of highways in the whole region had exceeded 200,000 km, of which 6,630 km were expressways and 7,790 km were first-class highways, with 1.6 billion tons of commercial freight volume and 298.56 billion tons of freight turnover volume completed, up 8.5% and 8% respectively year on year.

There are expressways in 12 cities in Inner Mongolia, and the number of expressways in county towns has reached 94, including 51 expressways. The major thoroughfare that runs through the eastern and western parts of Inner Mongolia has been completed according to expressway standards. Fourteen expressways and 16 first-class expressways have been completed. Manzhouli and Erlianhaote and other major ports are connected by first-class expressways, forming an open pattern of connecting the south with the north and connecting the east with the west.

The completion of 30 out-of-area access roads has solved the problem of poor export between Inner Mongolia and other provinces and autonomous regions. Inner Mongolia is organically integrated with the port highway networks of North China, Northeast China, Northwest China and neighboring countries. It has unblocked the economic trunk lines from all parts of Inner Mongolia to the major markets in the mainland and to the sea in Xinjiang. It has effectively promoted the transformation of Inner Mongolia's resource advantages and location advantages into economic advantages. It is of great significance to the county economic development, industrial structure adjustment and economic development mode transformation in the areas along the line.

3.2 Problems Existing in the Development of Highway Transportation in Inner Mongolia

The Inner Mongolia has achieved great-leap-forward development in road transportation, supply capacity and service level. However, from the perspective of developing a comprehensive transportation system, highway transportation there are still some problems and deficiencies in development.

Firstly, the total amount of transportation infrastructure is still insufficient and structural contradictions are still prominent. Highway network density is only 1/3 of the national average, with high-grade highways accounting for only 14.7% of the total mileage, and ordinary national and provincial highways with thousands of routes. There are still 7,625 km of middle and fourth grade roads, other roads and unconnected roads, accounting for more than 20% of the total mileage. There are still 6,884 km of unconnected sections in the expressway network, and the whole expressway skeleton network has not yet been established. There are obvious differences in the regional development of the highway network in the whole region, and the development of the highway transportation facilities in each alliance city is unbalanced. Due to the slowdown of macro-economic development, difficulties in credit financing for highway construction, land, resources, environment and other factors, the expressway construction process in the whole region is slow.

Secondly, the contradiction between the demand for and supply of funds for transportation development is more prominent, the protection of public finance is obviously insufficient, the credit financing policy has bottlenecks, and the environment for attracting social capital to enter needs to be improved. With the transformation of economic development and the reduction of coal demand, the economic development of the autonomous region has been obviously impacted, the financial revenue of governments at all levels has been reduced, and the pressure of raising supporting funds for highway construction has become prominent. The rising cost of highway construction, the falling traffic volume and the poor efficiency of highway toll collection have affected the investment of social capital. With the deepening of reform, the investment policy environment for long-term support for highway construction has changed dramatically, and the contradiction between the demand and supply of funds for transportation development has become more prominent.

Thirdly, the service level of highway transportation needs to be improved, and there is insufficient effective connection and interaction with other modes of transportation. The general public transportation service has not yet been effectively met. The development of the comprehensive transportation system in the whole region is still in the initial stage. The transportation development between regions and urban and rural areas is uncoordinated. The effective connection between various modes of transportation is still not smooth. The level of transportation service needs to be further improved. The development of integrated transportation is slow. There is still a certain gap between the basic public services for urban and rural passenger transportation and the expectations of the people. The unreasonable organization of freight transportation structure has not been fundamentally reversed. The proportion of transportation costs in logistics costs is still high.

Fourthly, the highway maintenance management system is not smooth, the capital investment is insufficient, and the maintenance technology content is low. The division and multi-head management of the highway management industry in the whole region are serious, which affects the exertion of the management functions of the industry and the overall benefits of the road network. The investment in highway maintenance funds is insufficient, preventive maintenance cannot be followed up in time, and maintenance projects such as large and medium-sized maintenance and reconstruction of dangerous bridges cannot be arranged and implemented in time. Highway maintenance in rural and pastoral areas has not yet established a stable and reliable financial guarantee system. The scientific and technological content of highway maintenance in the whole region is still at a relatively low level compared with similar regions in the country. Highway maintenance technology is single and backward, and advanced highway maintenance technology and technology have not been applied and popularized.

4 Data Comes from Research Methods

4.1 Data Sources

This paper selects GDP, highway mileage and passenger and freight transportation turnover to analyze the correlation between economic development and various data of highway transportation. The data in this paper are mainly from the statistical yearbook of inner Mongolia from 2000 to 2017.

4.2 Research Methods

- Correlation coefficient

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{1}$$

$$r = \frac{\sum_{i=1}^{n} x_i y_i - n\overline{xy}}{\sqrt{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2} \cdot \sqrt{\sum_{i=1}^{n} y_i^2 - ny^2}} \tag{2}$$

Where, $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$ are the mean values of samples x and y, generally x is the independent variable and y is the dependent variable; $i(i = 1, 2, 3, \ldots, n)$ is the number of samples.

- Analysis on Economic Elasticity Coefficient of Transportation

The elastic relationship between transportation and economic growth refers to the comparative relationship between the growth rate of transportation volume and the growth rate of GDP, which is usually defined as the ratio of the growth rate of transportation volume to the growth rate of GDP. Obviously, if the transportation supply of a country or region can meet the demand of transportation, the elasticity coefficient calculated on the basis of the actual transportation volume of the transportation system can reflect the elasticity relationship between transportation and economic growth. For a given two departments (represented by variables x and y respectively) with a certain relationship in the economic and social system, the elastic relationship between them can be expressed by digital relationship, and its calculation equation is:

$$e = \frac{d_x}{x} / \frac{d_y}{y} \tag{3}$$

Among them, e the economic elasticity coefficient of highway transportation, x is the total amount of highway transportation, d_x is the growth amount of highway transportation, y is the total amount and d_y is the GDP growth amount. In the equation, $e = 1$ shows that the highway transportation and GDP in Inner Mongolia are increasing simultaneously. $e > 1$ shows that the growth of highway transportation in Inner Mongolia is faster than that of GDP. $e < 1$ shows that the growth of highway transportation in Inner Mongolia is slower than that of GDP.

- Grey Correlation Analysis

The general abstract system, such as social system, economic system, agricultural system, ecological system, etc., contains many factors, and the development trend of the system is determined by the result of the combined action of many factors. Among the numerous factors, which are the main factors, which are the secondary factors, which have a great impact on the system development, which have a small impact on the system development, which have a promoting effect on the system development, which need to be strengthened, which have an hindering effect on the system development and need to be suppressed, these are all issues that people are generally concerned about in system analysis. This paper will use grey correlation analysis to calculate which factors in Inner Mongolia highway transportation system have great influence on the development of regional economy and play a driving role in the development of regional economy, while which factors are restricting the development of Inner Mongolia regional economy and need to be strengthened.

Including economic development sequence group (X_i) and transportation sequence group $\left(Y_j\right)$. Among them, X_i including 5 indicators, Y_j including 4 indicators.

The initial value transformation is adopted for dimensionless treatment, and the calculation equation is as follows:

$$f(X_i(k)) = x_i(k)/x_i(1) \qquad X_i(1) \neq 0 \tag{4}$$

$$f\left(Y_j(k)\right) = y_j(k)/y_j(1) \qquad Y_j(1) \neq 0 \tag{5}$$

The correlation coefficient is the premise for calculating the correlation degree, and its calculation equation is:

$$\xi_{ij} = \frac{i^{min} j^{min} \left| X_i'(k) - Y_j'(k) \right| + \rho_i^{max} \rho_j^{max} \left| X_i'(k) - Y_j'(k) \right|}{\left| X_i'(k) - Y_j'(k) \right| + \rho_i^{max} \rho_j^{max} \left| X_i'(k) - Y_j'(k) \right|} \tag{6}$$

Among them, $\xi_{ij}(k)$ is the correlation coefficient between the first economic development index and the first transportation index in Inner Mongolia. The sum $X_i'(k)$ is the normalized value between Inner Mongolia's first economic development index and $Y_j'(k)$ the first transportation index, which ρ is the resolution coefficient, with a general value of 0.5.

Since there are many correlation coefficients, which are inconvenient to compare, it is necessary to centralize the correlation coefficients into one value, and its calculation equation is:

$$\gamma_{ij} = \frac{1}{n} \sum\nolimits_{N=1}^{1} \xi_{ij}(k) (\mathrm{N} = 1, 2 \ldots \mathrm{n}) \tag{7}$$

Among them, γ_{ij} is the degree of correlation, N is the number of indicators, that is, the Inner Mongolia economic development indicators or transportation indicators selected in this paper.

The value range of correlation degree is 0–1 ($0 \leq \gamma_{ij} \leq 1$), the greater the value, the greater the correlation, when $0 < \gamma_{ij} \leq 0.35$ it is low correlation degree; For $0.35 < \gamma_{ij} \leq 0.65$ moderate correlation; When $0.65 < \gamma_{ij} \leq 0.85$ is higher correlation; When $0.85 < \gamma_{ij} \leq 1$, the correlation is high.

5 Empirical Analysis on the Correlation Between Economic Development and Highway Transportation in Inner Mongolia

5.1 Correlation Analysis Between Economic Development and Highway Transportation

Based on relevant data, Pearson correlation coefficient matrix can be obtained by using equation and SPSS software calculation. Through the matrix, the correlation coefficients of GDP and highway passenger turnover, highway freight turnover and highway mileage are 0.851, 0.919 and 0.931, the correlation coefficient of highway mileage and highway passenger turnover is 0.745, and the correlation coefficient of highway mileage and highway freight turnover is 0.879, all of which are significantly correlated on the confidence level of 0.01. It can be seen that the correlation coefficient with passenger turnover, freight turnover and highway mileage has reached above 0.7, indicating that the relationship between them meets the significant correlation requirements of statistics, and the correlation is relatively significant (Table 1).

Table 1 Correlation coefficient matrix of economic development and highway transportation indicators in inner Mongolia

Indicators	GDP	Highway passenger transport turnover	Highway freight turnover	Highway mileage
GDP	1.000	0.851	0.919	0.931
Highway passenger turnover		1.000	0.789	0.745
Highway freight turnover			1.000	0.879
Highway mileage				1.000

5.2 Analysis on Economic Development and Elastic Coefficient of Highway Transportation

In order to simplify the calculation process, this paper selects GDP as the measurement index of inner Mongolia's economic development, selects inner Mongolia's highway passenger turnover and highway freight turnover as the measurement index of inner Mongolia's highway transportation, and calculates the economic elasticity coefficient of Inner Mongolia's transportation through equation that can be seen Table 2.

The development of economic elasticity coefficient of highway cargo transportation in Inner Mongolia basically shows an upward trend from 2000 to 2015, and a downward trend from 2015 to 2018. From 2001 to 2018, the GDP of Inner Mongolia and the transportation economic elasticity coefficient of road transportation freight turnover are basically positive, which shows that the economic growth and the growth of road transportation are positively correlated. The economic elasticity coefficient of transportation is more than 1 in most cases after 2007, and the growth rate of road freight transportation is faster than the economic growth rate. With the rapid development of Inner Mongolia's economic base, road cargo transportation is well adapted

Table 2 Inner Mongolia transportation economic elasticity coefficient from 2000 to 2018

Year	Economic elasticity coefficient of passenger transport	Economic elasticity coefficient of cargo transportation
2000	0.65	0.61
2003	−0.28	0.20
2006	0.43	0.71
2009	0.71	1.03
2012	0.89	1.94
2015	−1.90	18.80
2018	−1.93	1.09

to the requirements of economic development. Road transportation has increased investment and accelerated the pace of development.

From 2001 to 2018, the elasticity coefficient of passenger transport turnover volume and GDP in Inner Mongolia gradually showed a downward trend, especially from 2012 to 2018, showing a significant year-on-year decline, basically below 0.6 and showing negative values, indicating that the growth rate of passenger transport seriously lags behind the economic growth rate. With the increase of per capita income, the travel demand of passengers is continuously increasing. The supply of passenger transport in Inner Mongolia cannot meet the demand of passenger transport. The passenger transport industry restricts the economic development of Inner Mongolia.

5.3 Grey Correlation Analysis of Economic Development and Highway Transportation

- *Construction of Index System*

In this paper, the economic development system of Inner Mongolia and the transportation system are analyzed by grey correlation degree, and the economic development system is constructed by using 4 indexes including the GDP of Inner Mongolia from 2000 to 2017 and the GDP of primary, secondary and tertiary industries. The statistical data of 5 indexes such as road mileage, road passenger turnover, road freight turnover and road network density are used as comparison series shown in Table 3.

- *Calculation of Correlation Degree*

Through equation, the correlation matrix is obtained after processing the original data of Inner Mongolia In the highway transportation system, the index with the highest correlation with GDP is the freight turnover X4, reaching 0.9307, which shows that the development of the freight transportation industry is closely related to the economic development. The average correlation degree between the turnover volume of goods and the three industries is also above 0.8, which is relatively

Table 3 Index system of grey correlation analysis between economic development and highway transportation in inner Mongolia

Highway transportation index	Indicators of economic development
X_1 highway mileage X_2 Expressway Mileage X_3 Highway Network Density X_4 turnover of goods X_5 passenger turnover	Y_1 GDP Y_2 Gross Output of Primary Industry Y_3 Gross Output Value of Secondary Industry Y_4 Gross Output Value of Tertiary Industry

Table 4 Grey correlation analysis index system of economic development and highway transportation in inner Mongolia

	X_1	X_2	X_3	X_4	X_5	Average
Y_1	0.8876	0.9142	0.8686	0.9307	0.7821	0.87664
Y_2	0.8256	0.9889	0.8458	0.8314	0.8344	0.86522
Y_3	0.8683	0.9578	0.9316	0.8615	0.7385	0.87154
Y_4	0.8482	0.9795	0.9248	0.8942	0.8104	0.89142
Average	0.8574	0.9601	0.8927	0.8794	0.7913	

high, with the development of goods transportation playing the most significant role in promoting the development of the tertiary industry. The highway mileage has the highest average correlation with economic development among all kinds of highway indexes, which shows that the highway development is the most closely related to economic development in the highway transportation system. Highway has obvious advantages to drive the circulation of goods in the region and integrate the independent economies in the region to promote the overall rapid development (Table 4).

6 Conclusions and Recommendations

Inner Mongolia highway traffic has a high degree of correlation with economy. Economic development has a positive impact on the development of highway traffic, which also greatly promotes economic development. Inner Mongolia is located inland. Highway transportation is the dominant mode of transportation in the autonomous region. After years of construction, highway traffic is at a stage of development in which it accelerates to form a network, steadily improves and integrates with comprehensive traffic, and pays equal attention to overall development. On the one hand, it is required to optimize the network layout, strengthen the connection of facilities, and vigorously improve the smooth level of infrastructure and the coverage of key cities and towns in the construction of highway transportation system.

We should speed up the construction of tourist passages and tourist highways, and strengthen the supporting and guaranteeing role of transportation in tourism. In accordance with the principle of seeking progress in stability and being moderately ahead of schedule, we should continue to improve the construction of transportation infrastructure, focus on strengthening weak links, continuously upgrade the technical level and construction standards of infrastructure, and improve the service capacity of transportation facilities. On the other hand, as the basic network of the comprehensive transportation system, highway transportation development should be based on its comparative advantages of wide coverage and close connection with public production and life, strengthen the connection with other modes of transportation, make overall and intensive use of channel resources, and optimize the allocation of channel capacity. Strengthen the connection with railway stations, airports and other transportation hubs, and improve the connection and conversion efficiency between roads and other modes of transportation.

In areas where the total amount of highway transportation infrastructure in Inner Mongolia is still insufficient, the transportation service letter needs to be improved, and there is still a certain gap with the national advanced level, it is even more necessary to speed up infrastructure construction, speed up the improvement of infrastructure network, vigorously promote modern transportation organization methods, comprehensively improve the overall supply capacity and comprehensive service level of transportation, and increase power and reserve stamina for optimizing the structure, improving quality and increasing efficiency in stable economic growth.

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Predicting Model of Crude Oil Price Combining Stochastic Time Effective and Factorization Machine Based Neural Network

Fang Wang and Menggang Li

Abstract This paper concentrates on the model, factorization machine based neural network (NN) with stochastic time effective function (FM-ST-NN), to predict the WTI crude oil price trend. The factorization machine technology makes the proposed model capable of grasping the interactive factorization among inputs. And the stochastic time effective function shows the effect of historical data's time on weights which reflects the impact on the predictive model. The forecasting results are compared with other methods including neural network and factorization machine based neural network. And the predicting performance are evaluated through the Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) accuracy measures.

Keywords Factorization machine · Neural network · Crude oil price prediction · Time random effects

1 Introduction

Crude oil forecasting is always a significant topic which has drawn a large amount of attention from the area of economy and finance. As some difficulties for disobeying the statistical assumptions in dealing with nonlinear and non-stationary time series when considering the crude oil price accurately, the predicting becomes more challenging.

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There are numerous and effective models proposed to for predicting crude oil price series. Besides some classical statistical models [1, 2], some models are developed based on machine learning technique in recent years [3–12]. From the machine learning approaches, support vector machine (SVM) [3–5] is one of the artificial intelligent based approaches which can capture the crude oil prices' volatility. Another popularly and frequently used model is neural network [6, 7]. Neural network has the advantages on capturing the nonlinear functional relation through the interconnected neurons and training modes. Some applicable types of neural networks like radial basis function neural network, recurrent neural network, wavelet neural network, etc [8–12] have also been utilized to predict financial time series. Consequently, hybrid methods [13, 14] and some neural network models combined with random jump or with random time effective [15–18] have been widely employed in forecasting.

Although the artificial intelligent based technologies have achieved markable results, there are still limitations. As far as we know, a large number of models do not pay attention to the interactions among the inputs with different scales of features. For example, most of the neural network models handle the non-linearities by the activation functions and they were widely used in some applications such as image processing, mechanical translation, speech recognition and so on. Factorization machine (FM) is firstly introduced by Rendle [19] who used it for collaborative recommendations. FM is an advantageous method in learning feature interactions. In contrast to the matrix factorization method which only model the relation between two entities [20], FM shows its flexibility. FM also has applications in industry and gives a promising direction for the prediction purpose in regression, classification and ranking [21–23].

In this paper, we combine factorization machine with neural network technique (FM-NN) for crude oil price forecasting. In order to show the effects of stochastic time on data in different time, we incorporate the stochastic time effective function [17] to modify the weights when computing the global error. It helps to modify the weights of the proposed neural network (FM-ST-NN) more effectively. To evaluate the model's performance, we select WTI crude oil data from January 3, 2012 to December 31, 2018. To show the advantages of the proposed FM-ST-NN model, we compare the predicting results with two neural network models including NN and FM-NN. The performance of different models are evaluated through three accuracy measures finally.

The rest of this paper is presented as follows. In Sect. 2, we give the prediction model FM-ST-NN. In this section, we first construct the model and introduce some needed ingredients. Then the algorithm of FM-ST-NN is given. Section 3 presents the main predicting results of FM-ST-NN model. The forecasting results shows more accuracy compared with the other two neural network models, i.e., NN and FM-NN. In Sect. 4, we highlight some necessary conclusions finally and give some directions for future work.

2 Methodology

2.1 FM-ST-NN (Factorization Machine-Neural Network with a Stochastic Time Effective Function)

In this section, we first describe a three layer neural network incorporating factorization machine ideas which is shown in Fig. 1. Compared with neural network, the main differences are located in the hidden layer from the structure. Be more concrete, the blue nodes receive data after the linear connections from the set of input neurons. And then compute the results through the nonlinear activation function' operation. But the red nodes compute the results through the activation function of the factorized interactions among the inputs.

The output of FM models all interactions between each pair of features, i.e., a linear interactions and an inner product of each feature. The estimating results of FM is

$$\begin{aligned}\hat{y}(x) &= w_0 + \sum_{i=1}^{n} w_i x_i + \sum_{i=1}^{n}\sum_{j=i+1}^{n} \langle \boldsymbol{v_i}, \boldsymbol{v_j}\rangle x_i x_j \\ &= w_0 + \sum_{i=1}^{n} w_i x_i + \frac{1}{2}\sum_{f=1}^{k'}((\sum_{i=1}^{n} v_{if} x_i)^2 - \sum_{i=1}^{n} v_{if}^2 x_i^2),\end{aligned} \tag{1}$$

where k' is a user-specified dimension parameter for feature x_i.

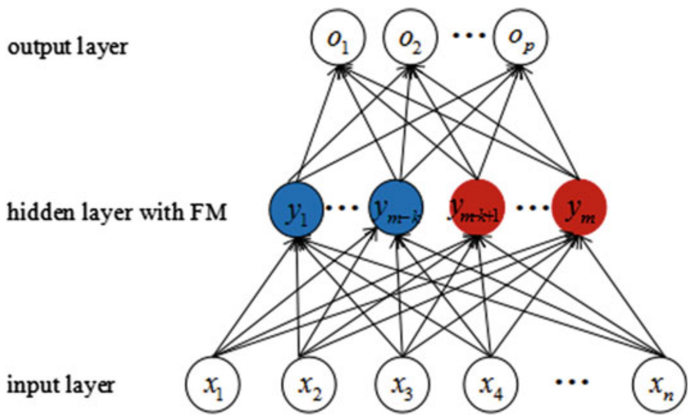

Fig. 1 The architecture of factorization machine-neural network

Suppose that there are n input features in the input layer, m neurons in the hidden layer and p output neurons in the output layer. Then, we describe the forecasting process of FM-ST-NN step by step below.

1). The hidden layer: the neurons in the hidden layer are partitioned into two parts:

$$y_j = f(\sum_{i=1}^{n} v_{ij}x_i), i = 1, 2, ..., n, j = 1, 2, ..., m - k, \tag{2}$$

$$\begin{aligned} y_{m-k+j} &= f(\frac{1}{2}((\sum_{i=1}^{n} \hat{v}_{i,m-k+j}x_i)^2 - \sum_{i=1}^{n}(\hat{v}_{i,m-k+j})^2 x_i^2)), \\ &i = 1, 2, ..., n, j = 1, 2, ..., k, \end{aligned} \tag{3}$$

where x_i is the value of ith node, y_j denotes the value of the jth node, v_{ij} is the linear weight relates the ith input node to the jth output node which is undetermined, $\hat{v}_{ij}$ is the latent weight corresponding to the ith feature which is also undermined, k is the user-specified dimension, and f is the activation function.

2). The output layer:

$$O_j = f(\sum_{i=1}^{m} w_{ij}y_j), j = 1, 2, ..., p, \tag{4}$$

where w_{ij} is the connection weight which is undetermined, O_j is the value of the jth node in the output layer.

3). The loss layer: the squared loss function is a commonly used loss function and the error of the sample e_{i_0} is computed as

$$e_{i_0}(t) = \frac{1}{2}\phi(t_{i_0})\sum_{j=1}^{p}(T_j(t) - O_j(t))^2, i_0 = 1, 2, ..., N, \tag{5}$$

where i_0 is the number of data sets, $\phi(t_{i_0})$ is the stochastic time effective function which can be referred to [17] given in Eq. (6), and T_j is the actual value from the output data sets.

$$\phi(t_{i_0}) = \frac{1}{\beta}\exp\{\int_{t_0}^{t_{i_0}} \mu(t)dt + \int_{t_0}^{t_{i_0}} \sigma(t)dB(t)\}, \tag{6}$$

where β is the time strength coefficient, t_0 is the time of the newest data in the data training set, and t_{i_0} is an arbitrary time point in the data training set. $\mu(t)$ is the drift function, $\sigma(t)$ is the volatility function, and $B(t)$ is the standard Brownian motion.

Then the total error of the output layer for average set in FM-ST-NN is defined as

$$
\begin{aligned}
l &= \frac{1}{N}\sum_{i_0=1}^{N} e_{i_0}(t) \\
&= \frac{1}{N}\sum_{i_0=1}^{N} \phi(t_{i_0})\frac{1}{2}\sum_{j=1}^{p}(T_j(t) - O_j(t))^2.
\end{aligned} \tag{7}
$$

To optimize the FM-ST-NN model, we often use the stochastic gradient decent method to update the weights until it achieves convergence. The algorithm of FM-ST-NN will be given in the following subsection.

2.2 The Algorithm of FM-ST-NN

The referred stochastic time effective function [17] which reflects the time random effects. When the events happened near, the investor will be affected heavily. The recent information has stronger effect than the old information does. It is used to modify the weights when training and finally predict the target more accurately. The training process of FM-ST-NN is detailed as follows:

(1). Choose five kinds of crude oil price related indexes as input data sets: daily opening price, daily highest price, daily lowest price, daily closing price and daily trade volume. Choose the closing price of crude oil price in the next trading day as the output (target) data sets. So there are five nodes in the input layer and one node in the output layer.

(2). Divide the sample data into training and testing data sets. Let the connective weights in vector $\boldsymbol{v}$ and $\boldsymbol{w}$ follow the uniform distribution on $(-1, 1)$.

(3). Give the stochastic time effective function value $\phi(t)$ according to some parameters. The transfer functions from the input layer to the hidden layer and the hidden layer to the output layer are both assumed as the sigmoid activation function.

(4). Predefined a minimum training threshold ε until the predicting result meet the standard rule. That is, if l is below the value ε, use the input data in the testing data sets to compute the prediction result (step 6). Otherwise, update the connective weights in the next step.

(5). Update the weights through the backward process and the goal is to minimize the value l. For the gradients of the weights in the output layer are computed as

$$
\Delta w_{ij} = -\eta\frac{\partial l}{\partial w_{ij}}, i = 1, 2, ..., m, j = 1, 2, ..., p, \tag{8}
$$

where η is the learning rate. So the update rule is

$$w_{ij} \leftarrow w_{ij} - \eta \frac{\partial l}{\partial w_{ij}}.$$

The gradients of the weights in the hidden layer are separately given by

$$\Delta v_{ij} = -\eta \frac{\partial l}{\partial v_{ij}}, i = 1, 2, ..., n, j = 1, 2, ..., m - k, \tag{9}$$

$$\Delta \hat{v}_{i,m-k+j} = -\eta \frac{\partial l}{\partial \hat{v}_{i,m-k+j}}, i = 1, 2, ..., n, j = 1, 2, ..., k. \tag{10}$$

So the update rule is

$$v_{ij} \leftarrow v_{ij} - \eta \frac{\partial l}{\partial v_{ij}};$$

$$\hat{v}_{i,m-k+j} \leftarrow \hat{v}_{i,m-k+j} - \eta \frac{\partial l}{\partial \hat{v}_{i,m-k+j}}.$$

(6). When the error l is below the predefined value ε, the predicting result for the output node p can be derived through

$$f[\sum_{j=1}^{m-k} w_{jp} f(\sum_{i=1}^{n} v_{ij} x_i) + \sum_{j=1}^{k} w_{m-k+j,p} f(\frac{1}{2}((\sum_{i=1}^{n} \hat{v}_{i,m-k+j} x_i)^2 - \sum_{i=1}^{n} (\hat{v}_{i,m-k+j})^2 x_i^2))].$$

3 Simulation Results and Evaluation

In this paper, we select the data of WTI crude oil from January 3, 2012 to December 31, 2018. At the beginning of modelling, all the data should be normalized. We use the formula

$$X' = \frac{X - \min X}{\max X - \min X} \tag{11}$$

to normalize the data in the range of [0, 1]. And it is easy to obtain the real value after predicting through converting as $X = X'(\max X - \min X) + \min X$.

We first use FM-ST-NN model predicting the crude oil price. The normalized data are divided into two parts: training data and testing data, with a proportion of 2:1. The number of neurons m in the hidden layer is 20 in the experiment and the maximum iteration number is 1000. The learning rate η is set as 0.03 and the minimum preset training threshold ε is 5×10^{-5}. As we considering the stochastic time effects on predicting, $\mu(t)$ and $\sigma(t)$ are assumed as

$$\begin{aligned}\beta &= 1,\\ \mu(t) &= \frac{1}{(b-t)^3},\\ \sigma(t) &= 1.\end{aligned}$$

Figures 2–3 show the prediction results for training data sets and for testing data sets respectively.

Then we compare the predicting results from FM-ST-NN with different neural network models, i.e., NN and FM-NN. To analyze and evaluate the predicting performance of different models, the accuracy measures with the corresponding definitions are used below.

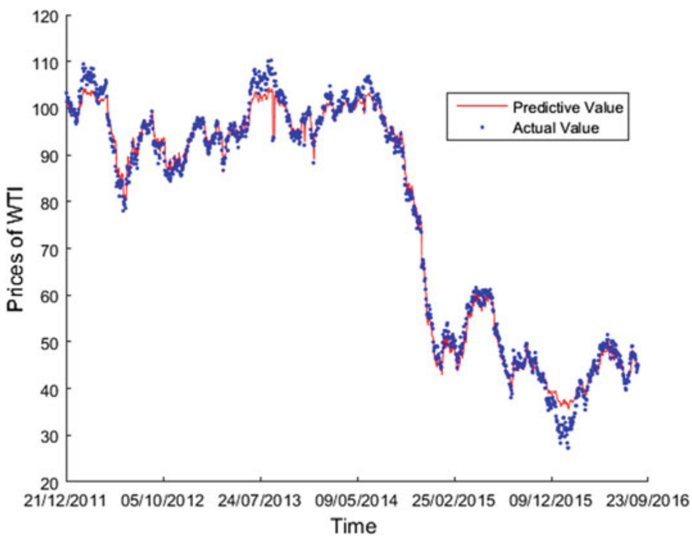

Fig. 2 The prediction results for training data sets ($k = 19$)

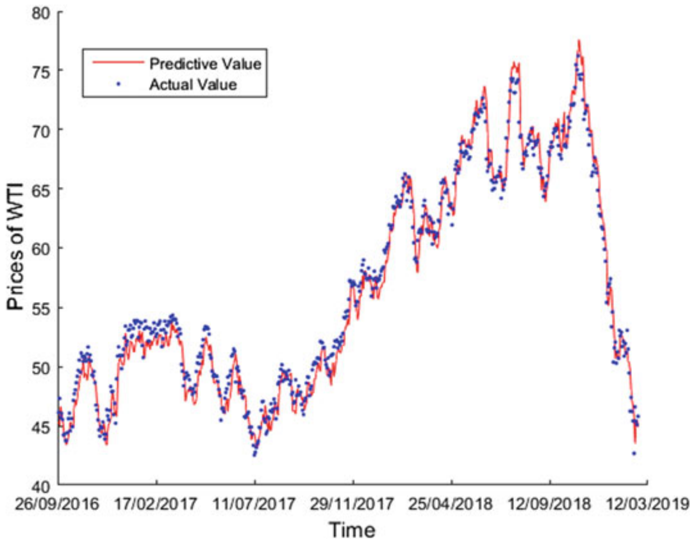

Fig. 3 The prediction results for testing data sets ($k = 19$)

$$MAE = \frac{1}{N}\sum_{i_0=1}^{N}\left|d_{i_0} - O_{i_0}\right|,$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i_0=1}^{N}(d_{i_0} - O_{i_0})^2},$$

$$MAPE = 100 \times \frac{1}{N}\sum_{i_0=1}^{N}\left|\frac{d_{i_0} - O_{i_0}}{d_{i_0}}\right|.$$

In order to know more clearly about the effects of factorization machine and stochastic time effect function, we evaluate the models through three accuracy measures listed in Table 1 and Table 2. Tables 1 and 2 give the performances of different predicting models, i.e., NN, FM-NN and FM-ST-NN on training data and testing data separately. From the two tables, we could find that both factorization machine technique and stochastic time effective function can improve the accuracies. And the FM-ST-NN model is the best among the other models on testing data. What's more, deep interactions among the input nodes will improve the accuracies.

Table 1 The performances of different predicting models on training data

Models	Training data		
	MAE	*RMSE*	*MAPE*
NN	1.952	2.550	2.803
FM-NN ($k = 3$)	1.867	2.436	2.859
FM-ST-NN ($k = 3$)	1.946	2.525	2.883
FM-NN ($k = 19$)	1.548	2.069	2.322
FM-ST-NN ($k = 19$)	1.710	2.289	2.686

Table 2 The performances of different predicting models on testing data

Models	Testing data		
	MAE	*RMSE*	*MAPE*
NN	1.341	1.691	2.314
FM-NN ($k = 3$)	1.312	1.583	2.357
FM-ST-NN ($k = 3$)	1.269	1.551	2.259
FM-NN ($k = 19$)	1.094	1.367	1.926
FM-ST-NN ($k = 19$)	1.056	1.340	1.896

4 Conclusion

In this paper, the factorization machines based neural network combined with stochastic time effective function has been studied to predict the WTI crude oil price. We constructed the proposed neural network model and gave the algorithm to illustrate the method. After the experiments, we compared the forecasting results from the FM-ST-NN model with the other two neural network models including neural network and factorization machine based neural network. The aim is to find the advantages of the proposed model. According to the three accuracy measures, i.e., the Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE), FM-ST-NN model performs better. The innovation of this paper is combining factorization machine and stochastic time effect with neural network for predicting. On one way, the effect of stochastic time on the predicting can be explored deeply. And on the other way, we believe that combine factorization machine technology in various algorithm design will be a future work tackling problems arising from different applications.

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The Promoting Role of Internet on the Upgrading of Consumption Structure in Rural Areas of Shandong Province

Xiaojuan Zhang, Yingsi Zhao, and Yuting Xu

Abstract Under the background of the strategy of "Internet plus" and "rural revitalization", the rural residents in Shandong Province still focus on surviving consumption, and the proportion of developmental and enjoyable consumption is not high. The consumption structure in rural areas is in urgent need of transformation and upgrading. Based on the data of 17 cities in Shandong province from 2007–2017, this paper constructed the panel data model, and then used F test, Housman test and other methods to study the impact of the Internet on the consumption structure of rural residents in Shandong province from both qualitative and quantitative aspects. The results show that the three indicators of Internet broadband penetration rate, smartphone penetration rate and per capita net income have significant positive correlation with the consumption structure of rural residents in Shandong province, and their promotion effect on the upgrade of rural residents' consumption structure increases in turn. Finally, based on the research data and conclusions, this paper proposes countermeasures and suggestions to promote the transformation and upgrading of consumption structure in rural areas of Shandong province.

Keywords Shandong province · Internet · Rural resident consumption · Upgrading consumption structure

1 Introduction

On February 19, 2019, the No. 1 Document of the Central Committee pointed out that it is necessary to adhere to the priority development of agriculture and rural

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areas and comprehensively promote rural revitalization. The proposal of rural revitalization strategy provides an important opportunity for the quality and efficient development of rural areas. Expanding the consumption demand of rural residents is a powerful measure to revitalize the countryside. Reviewing the development process of China's 40 years of reform and opening up, the expansion of consumption scale and the upgrading of consumption structure can effectively promote the overall improvement of the overall consumption level of society. At present, the Internet has become a new force to upgrade the consumption structure of rural residents. Internet consumption refers to the process of meeting the needs of consumers through the Internet platform [1]. The popularization and application of Internet and other information and communication technologies have made online consumption an increasingly popular way of consumption, and "Internet + rural" has further expanded the development space of online consumption. According to the data of the 41st report of CNNIC (China Internet Information Center), as of December 2017, the scale of rural netizens was 209 million, accounting for 27% of the country's Internet users. There is still room for further development and exploration of the huge rural consumer market. In 2017, Shandong province had a resident population of 100.583 million, making it the second largest province with a population of more than 100 million after Guangdong province. Its GDP reached 7267.818 billion yuan, ranking the third in China. As a province with a large population and a relatively high level of economic development, Shandong province has a strong representativeness in studying the influence of the Internet on the consumption structure of rural residents in China.

In the relevant literature, foreign scholars mainly analyze the impact of Internet development on consumer behavior, focusing on theoretical research, and have proposed many theories of consumer behavior. For example, Novak et al. measured the degree of customer experience under the network environment through a large number of user feedback information, and found that a good network environment can improve customer experience satisfaction, thus stimulating consumer desire [2]. Koufaris combined traditional consumer behavior with psychology to create a theoretical model of online consumer behavior [3]. Domestic scholars focus on empirical research, mostly through the panel data model to analyze. For example, in terms of theoretical and empirical research on the impact of the Internet on household consumption, Liu and Zhang pointed out that the development of the Internet has significantly promoted the consumption needs of rural residents, and further analyzed the differences between the eastern, central and western regions of China [4]. Chen and Liu used consumption data from 2002–2008 to empirically study the impact of farmers' income level on consumption structure by taking per capita income of rural residents as the entry point [5]. Liu studied the factors influencing the use of the network of rural residents, and made an empirical analysis of the farmers' online consumption intention and its influence degree by using the structural equation model. The study showed that the rural residents' online consumption intention was significantly affected by their behavioral attitude and degree of behavioral control [6]. Based on the theory of household consumption, Xiao pointed out that the promotion of urbanization has a significant pulling effect on the growth of rural residents' consumption, thus providing new ideas and solutions for promoting the upgrading of consumption structure in rural areas [7].

Through literature review, it can be found that domestic and foreign scholars have little research on the impact of the Internet on the consumption structure of residents. The main contribution of this paper is to innovatively study the upgrading of rural residents' consumption structure in Shandong Province from the perspective of the Internet, in order to provide corresponding countermeasures and suggestions for promoting the transformation and upgrading of consumption structure in Shandong Province, so as to provide some new ideas for promoting rural residents' consumption in the context of the new era and helping the transformation and upgrading of consumption structure in rural areas of China.

2 The Mechanism of Internet Development Promoting Rural Residents' Consumption

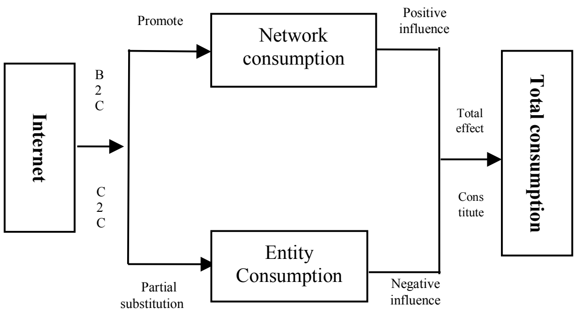
2.1 New Characteristics of Rural Residents' Consumption Behavior in Internet Economy

Firstly, the direct nature of the Internet has greatly released the consumption potential of rural residents, making rural residents' consumption more autonomous. The openness and interaction of the Internet enable rural residents to exchange information and trade with businesses directly. At the same time, the more abundant types of Commerce available on the internet, more timely information feedback and more personalized customized services have greatly stimulated the enthusiasm and initiative of rural residents' consumption, and also cater to the increasing demand of rural residents for high-quality life. Secondly, the convenience of the Internet enables rural residents to break through the limitations of time and space in traditional consumption and provide more choices. For example, "Internet + special bus" represented by "drip taxi" makes it more convenient for rural residents to travel; in addition, new consumption patterns such as online shopping and online booking also provide more choices for rural residents' daily life.

2.2 Mechanisms of Internet Promoting the Upgrading of Rural Residents' Consumption Structure

The overall consumption of residents includes network consumption and traditional consumption. At the same time, the mechanism of the Internet to promote rural residents' consumption includes both positive and negative effects. Positive effect refers to the promotion effect on total consumption by directly stimulating network consumption through B2C and C2C modes; Negative effect refers to that

Fig. 1 The influencing mechanism of internet on rural residents' consumption



the increase of network consumption causes the decrease of entity consumption, that is, network consumption has a substitution effect on entity consumption, which makes the Internet have a negative impact on entity consumption. The direct influence mechanism is shown in Fig. 1.

3 An Empirical Analysis of Internet Promoting the Upgrading of Consumption Structure of Rural Residents in Shandong Province

3.1 Model Setting

The main reasons for choosing panel data are as follows: First, panel data contains both cross-sectional and time dimension data, which can solve the problems that cross-sectional data or time series cannot solve respectively [4]. The data of 17 cities in Shandong Province selected in this paper during the 10-year period from 2007–2017 include both cross-sectional data and time series data, thus the panel data is the most appropriate choice; Secondly, panel data can not only provide more information about the dynamic behavior of individuals (i.e. the data changes of 17 cities in Shandong Province during 2007–2017), but also help to reduce the research errors caused by missing variables.

3.2 Index Selection and Variable Setting

(1) Selection of indicators

Because all the data used in this paper are macro statistical data, the availability of data should be fully considered in the selection of indicators. Therefore, this paper regards Internet broadband penetration rate and smart phone penetration rate as the direct measurement index of Internet development level in rural areas of Shandong Province. In addition, because income level has a significant impact on rural residents' consumption, this paper takes income as an indirect measurement index. In the selection of rural residents' consumption level indicators, the per capita consumption expenditure is taken as a measure of rural residents' consumption level. According to the division of consumption expenditure by the National Bureau of Statistics, Chinese residents' consumption expenditure can be divided into the following eight categories: food expenditure (X1), clothing expenditure (X2), residential expenditure (X3), daily necessities and services expenditure (X4), transportation and communications expenditure (X5), education, culture and entertainment expenditure (X6), medical and health care expenditure (X7), and other goods and services expenditure (X8).

(2) *Variable setting*
Interpreted variable: Y: per capita consumption expenditure of rural residents;
Explanatory variables: *Int*: rural broadband Internet broadband penetration rate;
Pho: rural smart phone penetration rate;
Inc: Per capita net income in rural areas;

The panel regression model is constructed as follows:

$$Y_{c,it} = \beta_0 + \beta_1 Int + \beta_2 Pho_{i,t} + \beta_3 Inc_{i,t} + \gamma_i + u_{i,t} \tag{1}$$

Among them, Y represents the per capita consumption expenditure of rural residents, and c represents 8 types of consumption expenditure. Then c represents 17 cities in Shandong Province, and t is time, and γ_i is an individual effect, and $u_{i,t}$ is a random error term.

Since heteroscedasticity may play a role in the final result, this paper takes natural logarithms of variables on both sides of the model (1) to eliminate the influence of heteroscedasticity. Establishment of panel data model (2):

$$InY_{c,it} = \beta_0 + \beta_1 lnInt + \beta_2 lnPho_{i,t} + \beta_3 lnInc_{i,t} + \gamma_i + u_{i,t} \tag{2}$$

3.3 Model Selection

Panel data models can be divided into mixed regression estimation model and fixed effect model. When conducting panel data estimation, the first thing to do is to test which model is more appropriate. Usually, F statistics are used to test:

$$F = \frac{SSE_1 - SSE_2(N-1)}{SSE_2/(NT-N-K)} \sim F(N-1, NT-N-K)$$

Where *SSE1* is the sum of squared residuals of the mixed regression model, *SSE2* is the sum of squared residuals of the fixed effect model, N is the number of individuals, T is the number of periods, and K is the number of explanatory variables.

After the test was passed, the Housman test was used to select individual fixed effect models or individual random effects models.

Null hypothesis: $H_0 = \hat{\beta}_{FE} = \hat{\beta}_{RE}$

Use the following statistics:

$$H = \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right)' \left[V_{\text{ar}}\left(\hat{\beta}_{FE}\right) - V_{\text{ar}}\left(\hat{\beta}_{RE}\right)\right]^{-1} \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right) \sim \chi^2(k) \quad (3)$$

Where $\hat{\beta}_{FE}$ is the estimated coefficient of the fixed effect, $\hat{\beta}_{RE}$ is the estimated coefficient of the random effect, and k is the number of explanatory variables. If the H value is large, the difference between the estimators is significant, and the null hypothesis is rejected accordingly, and the fixed effect model is selected, otherwise the random effect model is selected.

3.4 Data Description

This paper selects panel data of 17 prefecture-level cities in Shandong Province from 2007–2017. All variable data are from Shandong Statistical Information Network and China Internet Network Information Center (CNNIC). All data were analyzed using Stata 12.0 metrology software.

The relevant descriptive statistics are shown in Table 1. (T stands for unit of quantity, and Y stands for RMB yuan, and P stands for per capita.)

3.5 Analysis of Empirical Results

From Table 2, it can be seen that at the level of 1% significance (i.e. $P < 0.01$), every consumption model of rural residents in Shandong Province rejects the null hypothesis of the mixed model, so all models choose the fixed effect; at the level of 1% significance (i.e. $P < 0.01$), most consumption types pass the Housman test and choose the individual fixed effect model, only the total per capita consumption and food consumption. Expenditure did not pass the Housman test, so the individual random model was selected. In addition, the F/Wald values were tested under the 1% significance level, and the values of each model were above 90%, indicating that the overall fitting degree of the model was good.

Table 1 shows that the three indicators of Internet broadband penetration rate, smart phone penetration rate and per capita net income have a significant positive impact on the total consumption and various consumption expenditures of rural residents, and their impact is gradually increasing. As income is the most important factor

Table 1 Statistical description of variables

Variable	Representative meaning	Unit	Unit	Standard deviation	Mean	Maximum	Minimum
lnInt	Logarithm of Internet broadband penetration	T/100P	0.87	2.35	3.99	0.29	170
lnPho	Logarithm of smart phone penetration	T/100P	0.60	4.85	5.83	3.31	170
lnInc	Logarithm of per capita income	Y/P	0.40	8.95	9.77	8.04	170
lnY	Logarithm of per capita consumption expenditure of rural residents	Y/P	0.08	−0.82	−0.64	−1.06	170
lnY1	The logarithm of per capita food consumption expenditure of rural residents	Y/P	0.35	7.41	8.20	6.59	170
lnY2	The logarithm of per capita clothing consumption expenditure of rural residents	Y/P	0.51	5.77	6.89	4.55	170
lnY3	Logarithm of per capita living expenditure of rural residents	Y/P	0.45	6.69	7.79	5.22	170
lnY4	The logarithm of per capita living supplies and service consumption expenditure of rural residents	Y/P	0.49	5.63	6.51	4.07	170
lnY5	Logarithm of per capita transportation and communication expenditure of rural residents	Y/P	0.48	6.28	7.88	5.06	170

(continued)

Table 1 (continued)

Variable	Representative meaning	Unit	Unit	Standard deviation	Mean	Maximum	Minimum
lnY6	The logarithm of per capita cultural, educational and entertainment consumption expenditure of rural residents	Y/P	0.43	6.15	7.44	5.19	170
lnY7	The logarithm of per capita health care consumption expenditure of rural residents	Y/P	0.55	5.71	6.80	4.24	170
lnY8	Logarithm of consumer spending on other household goods and services per capita	Y/P	0.53	4.34	5.78	2.82	170

in determining consumption, especially in rural areas with low per capita income, the impact of per capita income on rural residents' consumption expenditure is much higher than the Internet broadband penetration rate and smartphone penetration rate. But on the whole, the development of the Internet has played a significant role in promoting the consumption expenditure of rural residents in Shandong Province.

Specifically, the penetration rate of Internet broadband has a significant positive impact on rural residents' consumption expenditure. For every 1% increase in the penetration rate of Internet broadband, rural residents' consumption expenditure increases by 0.189%. From the perspective of consumption types, the three consumption expenditures of food, housing and clothing are most affected by the penetration rate of Internet broadband. The penetration rate of Internet broadband increases by 1%, per capita food consumption expenditure increases by 0.139%, residential consumption expenditure increases by 0.328%, clothing consumption expenditure increases by 0.258%. The second is the consumption expenditure of living goods and services, transportation and communication expenditure, and the penetration rate of Internet broadband. For every 1% increase, the expenditure on daily necessities and services increased by 0.252%, and the expenditure on transportation and communications increased by 0.241%. The Internet broadband penetration rate had the least effect on the expenditure on cultural, educational, entertainment and medical and health care consumption. For every 1% increase in Internet broadband penetration, cultural, educational and entertainment consumption expenditure increased by 0.147% and medical and health care consumption expenditure increased by 0.132%.

Table 2 An analysis of the impact of internet on the consumption structure of rural residents in Shandong Province

Explanatory variables	Total expenditure per capita	X1	X2	X3	X4	X5	X6	X7
Int	0.189 *** 0.015	0.363 *** 0.014	0.258 *** 0.065	0.328 *** 0.023	0.252 *** 0.033	0.241 *** 0.036	0.147 *** 0.131	0.132 *** 0.051
Pho	0.267 *** 0.023	0.387 *** 0.034	0.341 ** 0.036	0.309 *** 0.067	0.324 *** 0.047	0.453 *** 0.025	0.418 *** 0.434	0.225 *** 0.131
Inc	0.431 *** 0.033	0.512 *** 0.015	0.393 *** 0.038	0.438 *** 0.065	0.454 *** 0.025	0.477 *** 0.030	0.619 *** 0.077	0.368 *** 0.035
Constant term	8.335 *** 0.028	5.781 *** 0.026	5.804 *** 0.022	1.71 *** 0.071	1.272 *** 0.021	2.061 *** 0.041	2.873 *** 0.073	1.433 *** 0.078
R^2	0.934	0.955	0.944	0.978	0.932	0.958	0.945	0.921
F/ Wald	3047.26	2566.14	486.02	366.57	180.44	403.46	178.34	199.72
F test	32.15 ***	17.19 ***	26.53 ***	18.27 ***	14.33 ***	9.638 ***	26.59 ***	20.64 ***
Housman test	4.40	2.46	17.88 ***	16.92 ***	10.67 ***	15.72 ***	17.25 ***	20.80 ***
Model selection	Random	random	random	random	random	random	random	random

Note: "*" represents the significance level of the statistical results, and "*", "**", "***" indicate the level of significance of 10%, 5%, and 1%, respectively. In general, $p < 0.05$ indicates that the difference between the data is significant, and the null hypothesis can be rejected.

The mobile phone penetration rate has also played a significant positive role in promoting the consumption of rural residents, and its promotion effect on various consumer expenditures of rural residents is better than the Internet penetration rate. For every 1% increase in mobile phone penetration rate, the per capita consumption expenditure of rural residents increased by 0.267%; with the popularity of smart phones, the price, performance and convenience of them have been more and more able to meet the needs of rural residents. It can be said that the dependence of rural residents on smart phones is much higher than that of computers, which has become an indispensable part of rural residents' daily life. Specifically, rural residents' expenditure on transportation, communication, culture, education and entertainment is most affected by the Internet. For every 1% increase in mobile phone penetration, the consumption expenditure increases by 0.453 and 0.418% respectively. Secondly, the expenditure on food, clothing and daily necessities and services increased by 0.387, 0.341 and 0.324% respectively for every 1% increase in smartphone penetration. The promotion effect of mobile phone penetration rate on rural residents' residential consumption expenditure and health care consumption expenditure is the smallest. For every 1% increase in mobile phone penetration rate, their consumption expenditure increases by 0.309 and 0.225%, respectively.

4 Research Conclusions and Suggestions

It can be seen from the above analysis that the development of the Internet can promote the upgrading of rural residents' consumption structure in Shandong province. Internet broadband penetration rate, smart phone penetration rate and per capita net income have significant positive effects on the upgrading of rural consumption structure, which can promote the transformation of consumption structure from traditional survival consumption structure to enjoyment development consumption structure. Specifically, the Internet broadband penetration rate has a strong impact on rural residents' living consumption, but a slightly weak impact on enjoyable consumption; while the smart phone penetration rate has a higher impact on rural residents' enjoyable consumption and a weaker impact on living consumption, which indicates that the improvement of the penetration rate of smart phones in rural areas can promote the transformation of rural residents from the traditional living consumption structure based on clothing, food and housing to the consumption structure based on development and enjoyment. In addition, with the steady improvement of the per capita income level of rural residents, people's demand for improving the quality of life has become more and more intense. The development of enjoyable consumption such as online shopping and online education will gradually become the daily consumption of rural residents. Therefore, in the new era of "Internet +" economy, we should rely on Internet technology and gradually increase the income of rural residents, fully tap the network consumption demand of rural residents in Shandong, so as to further promoting the upgrading of consumption structure in rural areas of China and forming a new model of economic growth.

Based on the above conclusions, the following suggestions are put forward:

4.1 Vigorously Develop the "Internet + Agriculture" and Increase the Income of Rural Residents through Various Channels

It can be concluded from the research that per capita income has a significant positive impact on the consumption expenditure of rural residents, so it is necessary to give priority to improving income. On the one hand, it is necessary to strengthen the training of innovation and entrepreneurship for rural residents, and encourage them to start their own businesses and employment. For example, regular lectures and activities on entrepreneurship of rural residents are carried out to stimulate the initiative of rural residents to participate through the deeds of successful entrepreneurs. In addition, the government should give some preferential policies to farmers, such as tax deduction and exemption, special loan services, etc., to reduce the obstacles on the road of rural residents' entrepreneurship and eliminate their worries. At the same time through the Internet related media to promote entrepreneurship knowledge, improve the awareness of rural residents to start their own businesses. On the other hand, we should strengthen the investment of software and hardware infrastructure in rural areas, and take the construction of online and offline projects into account. Online construction of refined electronic trading platform for agricultural products, under the line to build large-scale agricultural demonstration base, the two together form a complete Internet + agricultural ecosystem, so as to help millions of rural residents through the Internet platform to achieve the industrialization and scale of agriculture, and then steadily improve the income of rural residents.

4.2 Strengthen the Construction of Internet Infrastructure to Achieve Full Coverage of Rural Networks

At present, the problems of poor broadband access ability, lack of 3G/4G signal coverage and insufficient information service platform exist in rural areas of Shandong Province. These long-standing drawbacks increase the difficulty of popularization and application of the Internet in rural areas. Therefore, the government should strengthen investment in the construction of Internet hardware and software infrastructure. On the one hand, the investment of hardware facilities such as optical cable, Internet access port and mobile phone base station should be strengthened; On the other hand, an all-round mobile phone service system should be established to meet the needs of rural residents for Internet access. Smart phones are simple to operate and easy to use, so mobile phones have become the main tool for rural residents to surf the Internet. The two-pronged approach promotes the Internet to take root in rural areas, so that the broad masses of the people have a greater sense of sharing the fruits of Internet development.

4.3 Build a Rural E-commerce Service System and Promote E-commerce into Rural Communities

In recent years, the scale of rural e-commerce users has increased significantly. Especially e-commerce transactions such as online shopping and online travel booking are widely welcomed by rural residents, which have strongly promoted the growth of rural residents' consumption demand and the transformation of consumption structure. In addition, rural residents are no longer solely satisfied with material life, and begin to pursue a higher level of spiritual and cultural life. Therefore, the construction of rural e-commerce service system and the promotion of e-commerce into rural communities have become an urgent need for the majority of rural residents. Firstly, we should strengthen the construction and improvement of logistics service system in rural areas, and concentrate on solving the "last kilometer" problem of logistics distribution in rural areas. The government should encourage Jing dong and other excellent logistics companies to invest in the construction of service stations in rural areas through subsidies or preferential tax policies, so as to improve the coverage of logistics in rural areas; Secondly, develop the main body of rural e-commerce, encourage and support various distribution centers, commercial and trade enterprises and other e-commerce entities to establish outlets in rural areas, so as to realize the existence of physical stores and virtual stores. Such as providing convenience services in rural communities, carrying out entertainment cultural activities and express self-service and so on.

5 Research Deficiency and Prospect

This study also has the following limitations, hoping to further improve these shortcomings in the future. Firstly, the selection of Internet development indicators is not comprehensive, only three representative indicators are selected, while other indicators of Internet development, such as the proportion of administrative villages opening Internet broadband services, the ratio of administrative villages through postal services, and the investment environment of rural Internet, have not been studied. In the future, these indicators can be further included in the scope of research to improve the accuracy of conclusions. Secondly, because the panel data models are based on macro-statistical data, the lag of data may have some impact on the results. In the future, we can update the data in time and constantly revise and improve the paper.

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Board of Directors and the Remediation of Internal Control Weaknesses

Ruyi Guo and Ping Chen

Abstract China's board of directors includes the audit committee and other committees. Existing researches focus on the governance role of the audit committee on internal control but ignore the research on other committees and internal control. This paper takes the listed companies with material internal control weakness in the Shanghai Stock Exchange and Shenzhen Stock Exchange from 2013–2016 as samples. This paper divides the board of directors into two levels: the audit committee and other committees. We find that in the internal governance of the company, the audit committee is conducive to promoting the remediation of internal control weaknesses, and other committees suppress the remediation of internal control weaknesses. This paper belongs to the same series with the author's graduation thesis, but the research level is different.

Keywords Board of directors · Material internal control weakness · Remediation

1 Introduction

Since the 21st century, several major financial fraud scandals such as Enron and WorldCom have erupted, which have made the society pay more attention to corporate governance. In several arrangements of company, audit committee is regarded as an important governance mechanism [1]. Many dissertations have researched the relationship of the audit committee and internal control. Du [2] found that the size of the audit committee helps to improve the quality of internal control. Liu [3] and Krishnan [4] also studied their relationship. The duty of the audit committee is to promote the establishment and improvement of internal control. Therefore, an effective audit committee can improve the quality of internal control in theory [5].

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By sorting out China's corporate governance mechanisms, it can be found that the audit committee is only a part of the board of directors. Although the audit committee has the duty to promote the remediation of internal control weaknesses, the duties of other committees are different. Different responsibilities may make the committee's work different. Unfortunately, existing researches are insufficient about that. This paper divides the board of directors into two levels, the audit committee, and other committees, and focus on the relationship between corporate governance mechanisms and the remediation of internal control weaknesses.

The innovations of this paper include two aspects. First, this paper separately studies the impact of the audit committee and other committees on the remediation of internal control defects and enriches the theory of corporate governance. Second, the paper sets a different indicator for remediation of internal control weaknesses and make up for the shortcomings of previous researches.

The following chapters of this paper are arranged as follows: the chapter two is theory and regulation. The chapter three is the theoretical analysis. The chapter four is the research design. The chapter five is the basic empirical results, and the chapter six is the research conclusion of this paper.

2 Theory and Regulation

A. *Principal-Agent Theory*

The development of productivity and the refinement of division of labor have led to the separation of the two powers in modern enterprises. The equity owners of enterprises cannot do their ownership well due to the limitation of professional knowledge and management knowledge, and the professional division of labor has also produced some professional operations. The human capital provider manager accepts the entrusted agent of the non-human capital equity capital to exercise the owner's power, and thus there exits the separation of management rights and ownership in the practice. In 1932, two American economists, Burley and Mein, proposed the famous principal-agent theory. Jensen and Meckling redefined the principal-agent theory in 1976, and believed that the principal-agent theory was essentially a contract.

Although the principal-agent theory solves the problem of business management, it also has a principal-agent problem. So as to solve this problem, the principal requires the manager to inform the company of the business situation through contract and institutional arrangements to solve the principal-agent problem. In the manager's employment contract, it is usually agreed that the manager should regularly report the financial status of the company and the results of the operation to the shareholders. At present, this institutional arrangement has become a statutory requirement for corporate law in various countries, and financial reporting has become the main way to alleviate the problem of agency. However, because managers enjoy the advantages of information processing, under the opportunistic tendency, managers may use their advantages to make moral risk behaviors that harm the interests of shareholders and provide false or low-quality financial reports. Therefore, shareholders need sound internal controls to reduce managers' moral hazard behavior and monitor financial reporting through an independent external audit. The internal control system and the audit committee system are the institutional arrangements for solving the principal-agent problem.

B. *Information Asymmetry Theory*

Information asymmetry is first reflected in the company between equity owners and managers. The internal control and audit committee are institutional arrangements to alleviate information asymmetry. Information asymmetry is also reflected between investors and managers. Investors often invest in listed companies based on financial reports, prospectuses and other information disclosed by listed companies, but this information can not only fully reflect the financial status and operating results of listed companies, but also provide false financial statements if managers have moral hazard behaviors. It will cause huge losses to investors and seriously affect the operational efficiency of the capital market. This phenomenon is also likely to cause adverse selection of the capital market. Therefore, investors are increasingly demanding the company's internal control information, and hope to understand the environment in which financial reports are generated through the design and operation of the company's internal control. Investors also hope that the company has a special internal supervision operation and auditor selection agency to ensure that the information disclosed by the listed company is fair and the auditor can independently audit the company's statements. The listed company actively discloses internal control information, which can transmit positive signals to the market and avoid adverse selection. In order to ensure financial quality, the regulatory authorities require the audit committee to monitor the design and operation of internal control over financial reporting and evaluate the effectiveness of internal control over non-financial reporting.

The audit committee can alleviate information asymmetry, but the system itself also has information asymmetry. Specifically, shareholders need people with financial professional background and experience to exercise the decision-making power of the external auditors. However, the professionalism of the members of the audit committee is only known by the members, and the shareholders are at a disadvantage in terms of information. The audit committee is responsible for its duties. The fulfillment of their responsibilities is also understood only by members of the audit committee. Information asymmetry between the audit committee and shareholders is likely to affect the efficiency of the audit committee.

C. *Corporate Governance Theory*

As a special committee under the board of directors, the audit committee has enhanced the independence of auditors, promoted the establishment and improvement of internal control, monitored the preparation of financial reports, and ensured the quality of audited financial reports, thereby alleviating shareholders and managers. The information is asymmetrical. The audit committee audits the process of generating financial reports, supervises the disclosure of financial reports, and reduces the possibility of managers providing false financial statements and disclosing false accounting information. In terms of laws and regulations, the audit committee has relevant norms to support the supervision and evaluation of internal control. In practice, the audit committee is responsible for the internal audit and external audit of the company. It is a bridge between internal and external audit communication. The special status enables the audit committee to supervise and evaluate the design and operation of internal control, promote the repair and improvement of internal control defects, and improve internal control quality.

D. *Regulation*

Since the promulgation and implementation of the Sarbanes-Oxley Act (2002), corporate governance reforms have been launched worldwide. The audit committee and the internal control system have received much attention from the regulatory authorities as two important corporate governance arrangements. As far as China's legal system is concerned, Code of Corporate Governance for Listed Companies in China (2002) points out different responsibilities of corporate strategy, audit committee, and other special committees. *The basic norms of internal control* (2010) further promoted the establishment of internal control system. One of the research bases of this paper is that China's laws and regulations have different regulations on the duties of special committees. Although they all belong to the board of directors, different responsibilities may make them have different attitudes toward internal control.

3 Research Hypothesis

A. *The Relationship between Board of Directors and Remediation of Internal Control Weaknesses*

The board of directors may influence internal control from three perspectives. First, the board of directors is responsible for the establishment and evaluation of internal control. If the internal control of a listed company has weaknesses, the board of directors should urge the manager to repair the internal control. Second, the board of directors represents the interests of shareholders. When internal control is flawed, the board of directors will actively remediate the internal control defects in order to protect the interests of shareholders. Third, the board of directors set up a secondary agency which is responsible for internal control matters, so the board of directors can indirectly affect the remediation of internal control defects.

Therefore, this paper proposes the following hypothesis:

H1: Board of directors can promote the remediation of internal control weaknesses.

B. *The Relationship between Audit Committee and Remediation of Internal Control Weaknesses*

As far as the nature of the audit committee, the audit committee is a governance reform selected by shareholders to represent the interests of them. If the company has internal control weaknesses, the audit committee which represents the interests of shareholders will urge the manager to repair the internal control weaknesses as soon as possible in case the company is exposed to high risks. Second, because the audit committee also has the adverse selection and moral hazard, the listed company will also supervise the works of the audit committee. Due to its reputation, the audit committee has the pressure and motivation to perform its governance duties on internal controls. The audit committee's responsibilities include the appointment of external auditors and supervision of internal audit. In the process of communicating with CPAs and internal auditors, the audit committee can also obtain relevant information about internal control.

Therefore, this paper proposes the following hypothesis:

H2: Audit committee can promote the remediation of internal control weaknesses.

C. *The Relationship between Other Committees and Remediation of Internal Control Weaknesses*

Although it belongs to the board of directors, different committees have different jobs and responsibilities. While overseeing internal control is an important responsibility of the audit committee, other committees such as the compensation committee will not pay attention to this work. If the scale of other committees is large, and the authority of other committees on the board of directors is great, the focus of the company's work will be transferred to the duties of other committees. This situation will theoretically not be conducive to the remediation of internal control defects.

Therefore, this paper proposes the following hypothesis:

H3: Other committees are harmful to the remediation of internal control weaknesses.

4 Research Design

A. *Sample Selection and Sources*

This paper selects the A-share listed companies with material internal control weakness in the Shanghai Stock Exchange and Shenzhen Stock Exchange from 2013 to 2016 as samples. The sample screening criteria for this article are as follows [6]. In the end, this article obtained 444 effective sample companies. The specific sample screening values are not specifically listed due to space reasons. The data in this article comes from the CSMAR database, the DIB database and the website of the Shenzhen and Shanghai Stock Exchange. This article uses EXCEL and STATA 14 software for data processing (Table 1).

Table 1 Sample company screening criteria

No. 22 of the audit guidelines	Sample company screening criteria
CPA found fraud of directors, supervisors and senior management	A company that was punished by CSRC, Ministry of Finance, Shenzhen Stock Exchange and other departments for violating laws and regulations
Corporate corrected financial statements that have been published	(1) A company that corrected the annual report of the previous year; (2) A company that correcte the financial statements that have been published in the current year
The CPA found that there was a material misstatement in the current financial statements, but the misstatement was not found during the internal control operation	The non-standard audit opinion was issued by the external auditor, and the non-standard opinion was caused by internal control reasons
Corporate audit committee and internal audit agency have no effective supervision over internal control	(1) The internal control self-assessment report disclosed material internal control weakness; (2) The internal control audit report was issued by the auditor with non-standard opinions, and the internal control audit report is issued by the auditor

B. *Variables*

This paper sets dummy variable ICDR based on the timeliness of companies receiving the unqualified audit opinion of the internal control. It can make full use of the auditor's screening and forensic role. In addition, there is a general research flaw in past researches. The size of the board of directors and the repair of internal control defects are not in the same period. However, the research in this paper overcomes this defect.

As with previous studies, many of the characteristics of AC affect the remediation of internal control weaknesses. But this article takes a simple approach and only studies the size of the committees.

This paper refers to the literature at home and abroad and selects control variables from the different perspectives of the company (Table 2).

C. *Equations*

This paper refers to the article by Goh [7] to construct the following logistics model. In order to avoid the multicollinearity, the variables are placed separately into the model.

$$\begin{aligned} L(ICDR) = {} & a_0 + a_1 BOD + a_2 SIZE + a_3 BIG10 + a_4 SC + a_5 ROE \\ & + a_6 STATE + a_7 DUAL + a_8 COMPLEX + a_9 FIR + a_{10} CR \\ & + a_{11} YEAR + a_{12} INDUSTRY \end{aligned} \tag{1}$$

Table 2 Variable description table

Variables	Symbols	Definition
Remediation of internal control weakness	ICDR	1 = the firm repair internal control weaknesses within the first year; 0 = the firm do not repair internal control weaknesses
Board of directors	BOD	The number of boards of director members
Audit committee	AC	The number of audit committee members
Other committees	OC	The number of other committee members
Total assets	SIZE	The ln of total assets
Type of external auditor	BIG10	1 = The audit office who audit internal control is one of the top ten accounting firm; 0 = otherwise
Changes in the structure of the share capital	SC	1 = The company's share capital structure changed; 0 = otherwise
ROE	ROE	Net profit/owner's equity
Nature of company	STATE	1 = State-owned enterprise, 0 = Non-state enterprise
Two jobs in one	DUAL	1 = The chairman of the board and manager are the same person; 0 = The chairman of the board and manager are not the same people
Company complexity	COMPLEX	(Inventory + accounts receivable)/ total assets
The shareholding ratio of the largest shareholder	FIR	The shareholding ratio of the largest shareholder
Current ratio	CR	Current assets/ current liabilities
Year	YEAR	Set the dummy variable for the year in which the company has internal control defects
Industry	INDUSTRY	Set dummy variables with the CSRC 2012 version of the industry code

$$
\begin{aligned}
L(ICDR) = {} & b_0 + b_1 AC + b_2 SIZE + b_3 BIG10 + b_4 SC + b_5 ROE + b_6 STATE \\
& + b_7 DUAL + b_8 COMPLEX + b_9 FIR + b_{10} CR + b_{11} YEAR \\
& + b_{12} INDUSTRY
\end{aligned} \tag{2}
$$

$$
\begin{aligned}
L(ICDR) = {} & c_0 + c_1 OC + c_2 SIZE + c_3 BIG10 + c_4 SC + c_5 ROE \\
& + c_6 STATE + c_7 DUAL + c_8 COMPLEX + c_9 FIR + c_{10} CR \\
& + c_{11} YEAR + c_{12} INDUSTRY
\end{aligned} \tag{3}
$$

5 Empirical Test and Result Analysis

A. *Descriptive Statistics*

The following table is the result of the descriptive statistics of this paper. The mean and median of ICDR is 0.72 and 1. This means that most companies fixed defects in the year the defects occurred. The mean and median of BOD is 8.75 and 9. In general, the board of directors of a listed company consists of 8–9 members. The mean and median of AC is 3.39 and 3. the mean and median of OC is 5.36 and 6. It can be seen from the values of the mean and median, approximately 33 to 40% of the board members are from the audit committee. The mean and median of SIZE is 22.28 and 22.24, Sample companies have large differences in asset size. The mean and median of BIG10 is 0.40 and 0, that means most sample companies employ non-big 10 accounting firms for auditing. The sample company's ROE is very different (Table 3).

B. *Multivariate Analysis*

Based on the value of ICDR, the paper divides the samples into two groups and compares the mean values and median value of different groups. Through the multivariate analysis, we can know whether there is a difference between a company that repairs internal control weaknesses and a company that does not fix internal control weaknesses. From t value we can know, two groups have a significant difference in AC(audit committee), OC(other committees), BIG10(external auditor), SC(share capital structure), ROE, STATE(state) and CR(current ratio). The approximately same conclusion can be obtained from the results of the z value (Table 4).

Table 3 Descriptive statistics

Variables	Mean	Median	Min	Max	S.d
ICDR	0.72	1	0	1	0.45
BOD	8.75	9	5	18	1.81
AC	3.39	3	1	6	0.88
OC	5.36	6	1	13	1.85
SIZE	22.28	22.24	18.48	27.70	1.26
BIG10	0.40	0	0	1	0.49
SC	0.58	1	0	1	0.49
ROE	0.07	0.04	−11.14	23.37	1.46
STATE	0.50	0	0	1	0.50
DUAL	0.20	0	0	1	0.40
COMPLEX	0.26	0.21	0	0.89	0.19
FIR	32.74	29.98	0.29	81.77	15.51
CR	2.09	1.34	0	31.29	2.87

Table 4 Multivariate analysis

Variables	T value	Z value
BOD	1.30*	1.50
AC	−3.03***	−2.87***
OC	2.72***	2.91***
SIZE	−2.09**	−1.31
BIG10	−1.23	−1.23
SC	−4.45***	−4.36***
ROE	1.51*	−3.65***
STATE	1.60*	1.60
DUAL	−0.89	−0.89
COMPLEX	−0.42	−0.21
FIR	0.09	0.49
CR	−2.73***	−2.91***

a. *, **, ***means significant at the 10, 5, 1% level

C. *Correlation Analysis*

This paper conducts a correlation analysis based on reference-related research in order to roughly discover the relationship between variables. The results are shown in the table below and *, **, ***means significant at the 10, 5, 1% level (Table 5).

We can find out BOD has nothing to do with ICDR. The AC is significantly and positively related to ICDR. OC are significantly negatively correlated with ICDR. This shows that H1 and H2 are correct.

D. *Logistics Regression*

The following table is the result of the logistics regression. First, the board of directors cannot promote the remediation of internal control weaknesses. This phenomenon is different from H1. The Audit Committee promoted the remediation of internal control weaknesses at 1% level of significance. This proves the correctness of H2 and shows that the audit committee is a good representative of the interests of shareholders. In China, the audit committee does seriously perform its duties of supervising internal control. Other Committees suppressed the remediation of internal control weaknesses at 5% level of significance. This shows that although other committees are part of the board of directors, they do not care about internal control. In order to perform their duties better, other committees may even sacrifice the remediation of internal control weaknesses. The audit committee and other committees have different attitudes toward internal control, resulting in different relationships between assumptions and results about the board of directors and internal control. The years and industries of the following regression results were controlled but not specifically listed (Table 6).

Table 5 Pearson correlation test

	ICDR	BOD	AC	OC	SIZE	BIG10	SC	ROE	STATE	DUAL	COMPLEX	FIR	CR
ICDR	1.00												
BOD	−0.06	1.00											
AC	0.14***	0.20***	1.00										
OC	−0.13***	0.89***	−0.28***	1.00									
SIZE	0.10**	0.24***	0.13***	0.18***	1.00								
BIG10	0.06	−0.00	−0.06	0.03	0.14***	1.00							
SC	0.21***	−0.02	−0.03	−0.01	0.13***	−0.06	1.00						
ROE	−0.07	0.03	−0.03	0.05	0.05	−0.04	−0.02	1.00					
STATE	−0.08	0.16***	0.10**	0.10**	0.12***	0.19***	−0.20***	0.03	1.00				
DUAL	0.04	−0.21***	−0.03	−0.19***	−0.11**	−0.07	0.08*	−0.04	−0.16***	1.00			
COMPLEX	0.02	−0.08*	−0.08	−0.04	−0.03	0.07	0.06	−0.06	−0.01	−0.01	1.00		
FIR	−0.00	−0.00	−0.02	0.00	0.302***	0.08*	0.01	0.05	0.20***	0.02	0.00	1.00	
CR	0.13***	−0.14***	0.06	−0.16***	−0.16***	0.07	0.12**	−0.02	−0.14***	0.10**	0.05	0.00	1.00

a. *, **, ***means significant at the 10, 5, 1% level

Table 6 Logistics regression

Variables	(1)	(2)	(3)
BOD	−0.08		
AC		0.53***	
OC			−0.18**
SIZE	0.34***	0.24*	0.35***
BIG10	0.33	0.42	0.36
SC	1.11***	1.21***	1.16***
ROE	−0.16	−0.18	−0.17
STATE	0.24	0.18	0.23
DUAL	0.24	0.38	0.20
COMPLEX	0.45	0.52	0.40
FIR	−0.01	−0.00	−0.01
CR	0.19**	0.18*	0.17*
Pseudo R2	0.19	0.21	0.20
Prob > chi2	0.00	0.00	0.00
Log likelihood	−213.26	−207.97	−210.55
Number of obs	444	444	444

b. *, **, *** means significant at the 10, 5, 1% level

E. *Robustness Test*

In order to avoid the influence of extreme values, the 1 and 99% tailing treatment of continuous variables in the above study was carried out in the robustness test. The regression results are shown in the table below. It can be found that the regression results are robust (Table 7).

This paper replaces the absolute value of AC with the audit committee's proportion of board of directors (BILI). In addition, China's existing regulations require that the size of the audit committee should be greater than or equal to three people. Therefore, this paper set a dummy variable named YAOQIU, if the audit committee is larger than three people. The value is 1 and otherwise the value of YAOQIU is 0. This article draws on Naiker's approach, If BOD and OC exceeds the industry average, the value is 1; otherwise, the value is 0 (Table 8).

The results of the robustness test are the same as the results of logistic regression. This proves that the conclusion of this paper is robust.

In order to test whether the results of this paper are robust, this paper replaces the original CR with LEV (ratio of liabilities to assets) (Table 9).

The results of the robustness test are the same as the results of logistic regression. This proves that the conclusion of this paper is robust (Table 9).

In fact, there are many factors that affect internal control. In the main test of this paper, only some of them are controlled. This paper has added GROWTH (growth

Table 7 Logistics regression results about tail processing

Variables	(1)	(2)	(3)
BOD	−0.07		
AC		0.48***	
OC			−0.17**
SIZE	0.32**	0.24*	0.34***
BIG10	0.36	0.44	0.38
SC	1.10***	1.19***	1.15***
ROE	0.49	0.35	0.44
STATE	0.27	0.20	0.25
DUAL	0.23	0.38	0.19
COMPLEX	0.50	0.55	0.45
FIR	−0.01	−0.01	−0.01
CR	0.19**	0.18*	0.17*
Pseudo R2	0.19	0.20	0.19
Prob > chi2	0.00	0.00	0.00
Log likelihood	−214.26	−210.09	−211.79
Number of obs	444	444	444

c. *, **, ***means significant at the 10, 5, 1% level

Table 8 Robustness tests about substitution index

Variables	(1)	(2)	(3)	(4)
BOD	−0.30			
BILI		3.79***		
YAOQIU			1.63***	
OC				−0.96***
SIZE	0.33***	0.31**	0.28**	0.31**
BIG10	0.31	0.39	0.41	0.38
SC	1.11***	1.21***	1.11***	1.27***
ROE	−0.15	−0.18	−0.17	−0.18
STATE	0.25	0.20	0.20	0.27
DUAL	0.26	0.22	0.33	0.15
COMPLEX	0.44	0.41	0.36	0.26
FIR	−0.01	−0.01	−0.00	−0.01
CR	0.19**	0.16*	0.18**	0.16*
Pseudo R2	0.19	0.21	0.20	0.21
Prob > chi2	0.00	0.00	0.00	0.00
Log likelihood	−213.19	−208.24	−209.99	−207.30
Number of obs	444	444	444	444

d. *, **, ***means significant at the 10, 5, 1% level

Table 9 Robustness tests about LEV

Variables	(1)	(2)	(3)
BOD	−0.07		
AC		0.53***	
OC			−0.18**
SIZE	0.36***	0.28**	0.37***
BIG10	0.28	0.38	0.32
SC	0.96***	1.05***	1.02***
ROE	−0.15	−0.17	−0.16
STATE	0.26	0.19	0.25
DUAL	0.26	0.39	0.20
COMPLEX	0.72	0.80	0.63
FIR	−0.01	−0.00	−0.01
LEV	−2.21***	−2.22***	−2.02***
Pseudo R2	0.20	0.22	0.21
Prob > chi2	0.00	0.00	0.00
Log likelihood	−209.48	−204.05	−206.89
Number of obs	444	444	444

e. *, **, ***means significant at the 10, 5, 1% level

Table 10 Robustness tests about GROWTH

Variables	(1)	(2)	(3)
BOD	−0.07		
AC		0.53***	
OC			−0.18**
SIZE	0.33***	0.24*	0.35***
BIG10	0.32	0.41	0.35
SC	1.11***	1.21***	1.16***
ROE	−0.16	−0.18	−0.17
STATE	0.25	0.18	0.23
DUAL	0.25	0.38	0.20
COMPLEX	0.44	0.52	0.40
FIR	−0.01	−0.00	−0.01
CR	0.19**	0.18*	0.17*
GROWTH	0.00	0.00	0.00
Pseudo R2	0.19	0.21	0.20
Prob > chi2	0.00	0.00	0.00
Log likelihood	−213.20	−207.86	−210.49
Number of obs	444	444	444

f. *, **, ***means significant at the 10, 5, 1% level rate of operating income), and the results of the regression are as follows. The results of the robustness test are the same as the results of logistic regression. This proves that the conclusion of this paper is robust.

6 Conclusions

This paper focus on the relationship between the board of directors and the remediation of internal control weaknesses in two levels and verifies the relationship between the audit committee and other committees. The conclusion of the article is that only the audit committee is concerned about internal control, and other committees cannot promote the remediation of internal control weaknesses.

The study also found that the internal control defects are repaired more timely when the share capital structure changes and the Current ratio is large.

The research flaws in this paper are also obvious. First, this paper only studies from the perspective of scale and does not involve other committee characteristics such as gender, independence, and professionalism. Second, In this study, only A-share listed companies are studied. There is no classification study on different property rights, auditor types, and stocks. Third, because identifying internal control defects is difficult in related research, although this paper identifies the company with internal control weaknesses according to the mainstream research in China, it is inevitable that there are defects or missing samples. Subsequent research can carry out detailed research. In terms of future research directions, it is also possible to study the relationship between membership heterogeneity of the committee and the ICDR.

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An Empirical Study on the Impact of the Food Price on Food Security in China

Sai Tang, Tian Xu, and Zi Tai Wang

Abstract As the most populous country in the world, China faces significant food pressures. Therefore, the issue of food security has become an important issue that cannot be evaded on the road of China's great revival. Food security is a complicated condition requiring a holistic approach to all forms of malnutrition, the productivity and incomes of small-scale food producers, resilience of food production systems and the sustainable use of biodiversity and genetic resources. The purpose of this paper is to identify how the price fluctuation can influence the situation of food security in China. In the quantitative analysis part, Entropy weight method is used to analyze coefficient of the price and food security. We found the price factor is not the most important one which influences food security while the other two factors: net income per acre, national fiscal expenditure on agriculture are even more important. Based on the analysis, we give the following policy recommendations: (1) taking steps to improve the agricultural production capacity, (2) developing the ecological agriculture, (3) enlarging the agriculture insurance to make sure protect the profit of rural farmers, (4) relying on the "One Belt and One Road" strategy to further participate in global food and grain security, (5) speeding up the formulation of a food security law.

Keywords Food security · Three basic foods · Fluctuation introduction

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1 Introduction

Food security is a condition related to the availability of food supply, group of people such as ethnicities, racial, cultural and religious groups as well as individuals' access to it. It is the "availability at all times of adequate, nourishing, diverse, balanced and moderate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" Later definitions added demand and access issues to the definition. The final report of the 1996 World Food Summit states that food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." We must ensure China's food security so that we always have control over our own food supply, emphasized by President Xi Jinping. Agricultural modernization has steadily advanced, with annual grain production reaching 600 million metric tons over the past five years. It is important not only for the Chinese Economy Security but also for the sustainable development of the entire society. Therefore, ensuring the food market supply, ensuring food price stability, improving the food emergency reserve system, and minimizing food security risks are government responsibilities and an important part of the food security system. Regardless of the stage of economic progress, food security is a constant topic.

2 Literature Review

Malthus believes that the population increases geometrically, and food can increase in an arithmetic progression. Therefore, food tension will always exist. While China, the country with the biggest population has solved this problem after 1978 when Reform and Opening up policy enforced by the government. How does the country make it and what are the influence factors are the main concerns of this paper.

First, the situation of China's food security's evaluation standard, which should be as objective as possible, must be considered. Until now, a large number of scholars have evaluated the state of food security in China. Li pointed out that China's food security is in a state of tight balance [1]. Cui emphasized that China has basically solved the problem of food and clothing for the population of 1.4 billion. It uses 7% of the nation's cultivated land to feed nearly 20% of the population and officials believe that ensuring a high yield of the three basic foods will safeguard food security, resources, the environment, and sustainability [2]. On the other hand, Lester predicted that China's grain demand will reach 651 million tons (calculated by assuming a population of 1.63 billion people) in 2030, while actually the total grain output was 267 million tons in 1994, and the gap between the supply and demand of grain was as high as 384 million tons, and the self-sufficiency rate of grain in China fell to 41% [3].

Second, after understanding the overall evaluation of China's food security, we should further study how to specifically assess China's food security situation. To this end, it is necessary to construct a corresponding evaluation index system. Zhu constructed five indicators of food fluctuation coefficient, food self-sufficiency rate, grain reserve level, per capita food possession and low-income class food reserve level as indicators for evaluating food security system [4]. Fu et al. conducted an evaluation index system from the perspectives of the proportion of food insecure population, food security risk and resource pressure level. He believed that the proportion of China's food insecure population is decreasing year by year; the pressure of cultivated land is in tight balance; the risk of low food price has greater potential risks [5]. Yao et al. established an evaluation index system for China's food security from 1990 to 2011 using entropy method, founded on 18 specific indicators from four levels: food production resources, food availability and stability, food availability and food utilization level [6].

Finally, due to the complexity and diversity of the evaluation index system, scholars mainly focus on four aspects. (1) Agricultural resources, such as cultivated land resources and water resources will have an effect on food security. Han et al. believe that cultivated land resources are the most basic material conditions for agricultural production, and their quantitative changes have a direct impact on grain production and thus affect food security [7]. Nie believes that the essence of food security is the problem of farmland security and farmland is irreplaceable for food production [8]. (2) The population and population structure are also important factors affecting food security. Feng believes that with the population growth and consumption expansion, China's future arable land scale and per capita arable land area will further decline, and the per capita food consumption level and total food demand will further increase [9]. (3) There is also a relationship between urbanization and food security. Cai took Henan Province as a research object and found that the rapid development of urbanization has brought constraints on food production. A large number of rural laborers have been transferred to cities. The expansion of urban areas has led to the conversion of large-scale agricultural arable land to non-agricultural land, which has led to increasing pressure on food security [10]. (4) Agricultural technology affects food security to some extent. Du believes that agricultural technology advancement has a great impact on food security. It is necessary to increase investment in agricultural technology and increase the level of food security by adopting innovative agricultural technology [11]. In addition to the above factors, factors such as climate change and the quantity of imports and exports will also affect food security.

Scholars above have provided a lot of valuable reference suggestions for the evaluation and resolution of food security issues, but China's food security status is unique all around the world. The national food security strategy must ensure that the production of grain is basically self-sufficient and rations are absolutely safe. Based on the dietary habits of the people and the endowment of agricultural resources, the supply and demand of the three main foods have become an important determinant for safeguarding this strategic goal. This article focuses on three aspects: (1) An analysis of the impact of price fluctuations on food security; (2) An analysis of the main factors affecting the price changes of the three crops; (3) And a discussion of how to maintain their basic price stability, ensure adequate supply, and clarify the price fluctuations of the three basic foods.

3 Qualitative Analysis of the Relationship Between the Price of Agricultural Productions and Food Security

In order to identify the mechanism that how the price of agriculture production influences the food security, we choose three main foods: corn rice and wheat as samples to analysis. The reason we choose these three crops are as follows: (1) These three foods can be produced in large areas and on a large scale. The main planting area of the three foods accounts for more than 80% of the total planting area; (2) These three foods can be stored in large quantities for a long period of time. The main yield of the three foods accounts for more than 90% of the total grain output and China is about 95% self-sufficient in raising these foods; (3) These three foods can provide most people with the energy and the nutrients they need.

These main foods produced, processed, and stored in China, and thus have important significance for national food security. In recent years, production and price fluctuations of the three basic foods have been basically stable. Figure 1 shows the changes in the output of China's three basic foods since 1998. It can be seen that under the backdrop of a continual increase in grain production in China since 2004, the production of the three basics also shows steady growth. Thus, China has laid a good foundation for food security.

As a complex system, food security has many influencing factors. The status of each link in the system will affect the security of the whole system to varying degrees, and each link will affect each other and work together in the food security system. Food price volatility and its operational status are among the important indicators for determining food security. Food prices are affected by many factors. Factors such

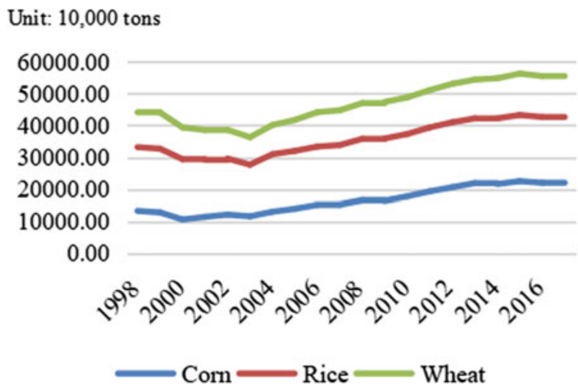
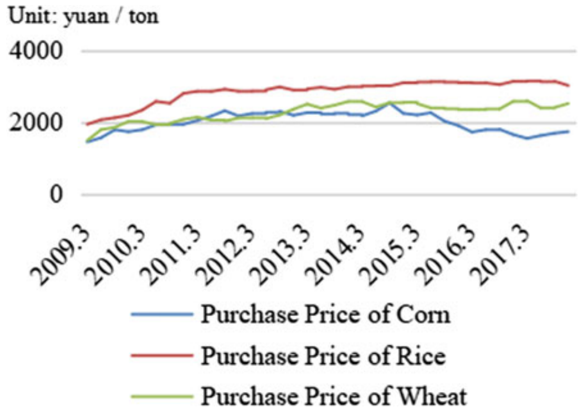


Fig. 1 Three main food's volume of productions in 1998–2017

Fig. 2 Purchase price of three main foods



as cultivated land area, production cost, expected profit level, government behavior, population, import and export volume, and reserve volume all affect food prices through the supply of output and market demand, which makes the grain market unstable and affects food security. In terms of prices, since the year of 2009, the prices of the three main foods have taken the purchase price as an example to show the following trends (Fig. 2):

Due to the special position of the three main foods in China, the impact of price fluctuations on food security is even more important. As can be seen from Fig. 2, grain purchase prices have been steadily rising since 2009, and have been in stable fluctuations from April 2011 to December 2013. In November 2014, the purchase price of corn reached its peak. Since January 2015, the purchase price of corn has dropped significantly. The change in grain prices at this stage is gradually showing a downward trend in the fluctuation. From 2014 to 2015, the purchase price of grain experienced a sharp rise and fall, which directly affected the income of hundreds of millions of farmers. Data shows that the sharp fall in food prices in 2015 may lead to a negative revenue growth of RMB 100 billion, which will be transmitted to the consumer market and will directly lead to a reduction in the scale of consumption. At the same time, the enthusiasm of farmers for grain production will decline.

4 An Empirical Analysis of the Impact of Price Changes of the Three Foods on Food Security

Based on the above-mentioned transmission mechanism, this paper determines that the food security evaluation index system contains three major subsystems: food price security, food supply security, and strategic food security. The research process adopts the 2002–2015 annual statistical data, uses the entropy method to conduct empirical analysis and tests, and uses the 2002 indicator data as the research base, which was chosen because China's grain marketization reform began that year.

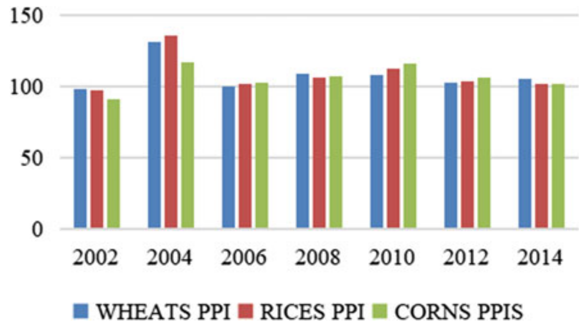


Fig. 3 Fluctuation of three main food's PPI index

The grain price security subsystem mainly adopts the grain production price index (PPI) as a measure of the price fluctuation of grain, and it conducts a descriptive analysis. At the same time, it compares horizontally the fluctuations of the three major staple food production price indexes (Fig. 3).

As can be seen from Fig. 3, the trends of the production price index of wheat, rice, and corn from 2002–2014 are roughly in line with the production price index of agricultural product, with the production price index of corn being most in line with the fluctuation of agricultural products. The production price index of rice and wheat showed the most significant increases in the rising stage. The production price index of wheat fluctuated from 2006 to the end and did not show any large increase or decrease.

From Fig. 4, it can be seen that the fuzzy change of the agricultural product production price index is wavy: the highest production price index reached 118.5 in 2007, and the lowest production price index was as low as 97.6 in 2009. The changes in the production price index of agricultural products are characterized by the mutual recurrence of peaks and valleys, with the exception of the large price volatility between 2007–2011 (a result of the effects of the global economic crisis) but prices have stabilized since 2011.

The food supply security subsystem mainly includes three indicators: grain output (10,000 tons), area under cultivation (thousands of hectares), and grain per capita (kg).

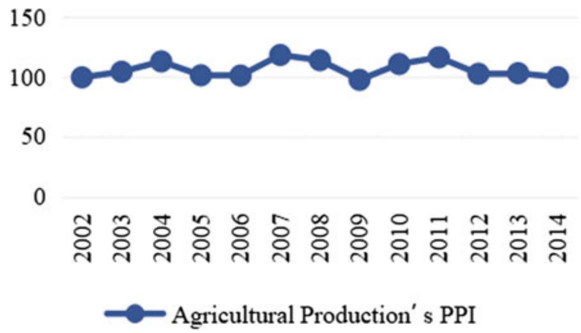


Fig. 4 Fluctuation of agricultural production's PPI in 2002–2014

According to the data source of Fig. 5, since 2003, the amounts have increased year by year, with grain output growing at the largest rate. Under the condition that the area under cultivation remains basically stable, the increase in food production ensures that the per capita food availability will increase year by year, thus ensuring security in the food supply.

The strategic security subsystem for food mainly includes three indicators: the import volume of the three major staple grains (10,000 tons), the per capita agricultural net income of rural residents (yuan), and the national fiscal expenditure on agriculture (100 billion). From Fig. 6, it can be seen that the imports of the three major staples have gradually increased since 2003. The expenditure on state financial support for agriculture has increased year by year, especially in the past four years, and the absolute amount of expenditure has increased tremendously. Before 2013, the agricultural per capita net income of rural residents was determined by

Fig. 5 Indicators of the supply security subsystem for food (2002–2014)

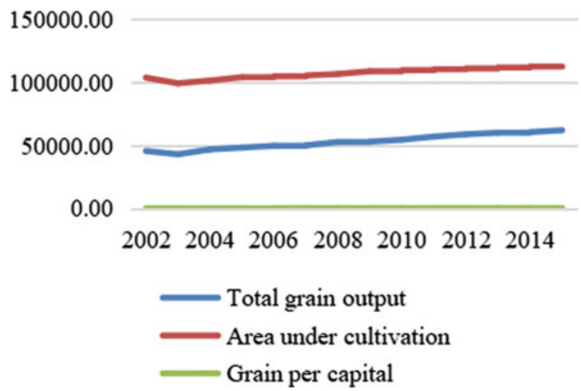
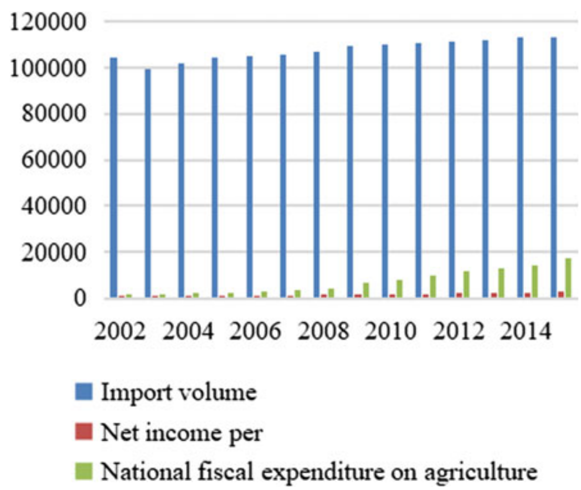


Fig. 6 Indicators of strategic security subsystem for food (2002–2015)



an independent sample survey. After 2013, the minimum income of the poverty line was used.

This paper uses the entropy method to analyze the relationship between the above three subsystems and food security. The first step in the analysis is to assign weights to each indicator and normalize the original matrix. Assuming that there are m indexes and n evaluation target systems for evaluation objects, the original matrix is D_{mn}, then we get a normalized matrix after standardized processing R_{mn}. The formula is as (1):

$$R_{mn} = \frac{D_{mn} - minD_m}{maxD_m - minD_m} \tag{1}$$

This paper gives 9 indicators $D_1\ D_2 \ldots D_9$which is $D_m\ \{D_1, D_2, \ldots.\ D_n\}$, Each individual indicator selects data from 2002–2015, hence, n = 14, the final normalization matrix has 126 data variables. Then we try to find the information entropy of the j index H_j, where H_j donates information entropy, and the formulas are as follows:

$$H_j = -k\sum\nolimits_{i=1}^{n} f_{ij} lnf_{ij} \tag{2}$$

J follows 1, 2·, m

$$k = ln\frac{1}{n} \tag{3}$$

$$f_{ij} = \frac{R_{ij}}{\sum_{i=1}^{n} R_{ij}} \tag{4}$$

$$f_{ij} = 0;\ \text{In}\ f_{ij} = 0$$

The third step is to find the weight of indicator. The formulas are as follows:

$$\omega_j = \frac{1 - H_j}{m - \sum_{j=1}^{m} H_j} \tag{5}$$

$$a\sum\nolimits_{j=1}^{m} \omega_j = 1 \tag{6}$$

j follows 1, 2·, m;

After the model construction of the entropy method is completed, the data is imported for inspection and implemented using the MATLAB program. The results are as follow (see Table 1):

The final result shows that: price security accounts for 0.0261, supply security accounts for 0.0319, and strategic security accounts for 0.9419. The rice production price index of the price security index is weighted at 0.0106, which is higher than the wheat and corn production price index weights. The weight of the total food production index in supply security is 0.0178, which is higher than that of the sown area and the per capita possession of food. The index of national fiscal expenditure on

Table 1 The result of entropy methods

Sub-system	Food safety evaluation index system and indicator weights		
	Individual indicators	*Unit*	*Weights*
Price security	Wheat production price index	%Base period (100)	0.0081
	Rice production price index	%Base period (100)	0.0106
	Corn production price index	%Base period (100)	0.0074
Supply security	Total grain output	10,000 tons	0.0178
	Area under cultivation	Thousand hectares	0.0022
	Grain per capital	kilogram	0.0119
Strategic security	Import volume	10,000 tons	0.0023
	Net income per acre	Yuan	0.197
	National fiscal expenditure on agriculture	Billion	0.7426

Sub-system	Food safety evaluation index system and indicator weights		
	Individual indicators	*Unit*	*Weights*
Price security	Wheat production price index	%Base period (100)	0.0081
	Rice production price index	%Base period (100)	0.0106
	Corn production price index	%Base period (100)	0.0074
Supply security	Total grain output	10,000 tons	0.0178
	Area under cultivation	Thousand hectares	0.0022
	Grain per capital	kilogram	0.0119
Strategic security	Import volume	10,000 tons	0.0023
	Net income per acre	Yuan	0.197
	National fiscal expenditure on agriculture	Billion	0.7426

[a]*Data sources* National Bureau of Statistics

agriculture expenditure in strategic security is 0.7426, which is higher than the import volume of the three major staple foods and the per capita agricultural net income of rural residents, and even higher than all index weights. Taken of rural residents, and even higher than all index weights. Taken together, the state financial expenditure on agriculture supports has the greatest impact on food security, followed by rural residents' per capita agricultural net income, with a weight of 0.1970.

From the above analysis results, it can be seen that the weight of price security is lower than the weight of supply security and strategic security, and it is contrary to the expectation that the price fluctuations of the three main staple foods have great impact on food security. This has an important relationship with China's inadequate food market reforms. Although through the country's macro-control of food security, it is able to obtain basic guarantees for food security against the impact of international food prices. These are non-market measures. In order to better protect China's food security, we must concentrate on supply-side reforms and step up the promotion of agricultural market-oriented reforms.

The supply security of grain accounts for more than 3% of the total. Among the three indicators, the maximum weight of total food production is 0.0178, and the minimum weight is the area under cultivation. In order to ensure the use of land for agriculture, the state strictly controls the red line of cultivated land, making China's agricultural land basically in a state of stability. The area under grain cultivation is the basic natural condition for guaranteeing food security. With the development of agricultural technology, its weight is gradually reduced in the food supply security. Food production accounts for the largest proportion in food supply security, which fully explains the continuous growth of grain production and the importance of ensuring the availability of food security.

The strategic security of food was unexpectedly the largest, accounting for more than 94%, and almost more than 40 times the weight of food price security. Among them, the government's expenditure on supporting agriculture accounts for a maximum of 0.7426, that is, small fluctuations in state fiscal expenditure on agriculture will have a major impact on food security. The influence of national strategic support on food security plays a decisive role. At the same time, the per capita net income of rural households in agriculture ranks the second place, indicating that the state's fiscal subsidies for agriculture and national transfer payments have significant incentives for agricultural personnel. The decisive significance of safeguarding food security lies in the national strategic planning, reforming the structure of the supply side of agriculture and ensuring that grain production increases.

5 Conclusions and Policy Recommendations

The proportion of food price security is less than that of grain supply security and grain strategic security, indicating that drastic food price fluctuations will have an impact on food security. However, food supply security and small fluctuations in strategic food security can also have a major impact on food security. The empirical test results prove that measures must be taken to ensure China's food security from the following aspects:

(1) China's grain is in a state of "dynamic balance", which means that the food security situation is generally stable and the security guarantee capability is continuously enhanced. However, food security in different regions, different time periods and different varieties is in a dynamic state, and the factors of insecurity and instability have not been completely eliminated. From the perspective of the basic standards for measuring food security, China is in a relatively safe range. However, from the long-term development trend, China's food security problem still exists, and the food security foundation needs to be further strengthened.

(2) At present, the main contradiction of China's agriculture has turned from a lack of product to a structural contradiction. The focus of ensuring food security has shifted from focusing on total volume to quantity and quality. Optimizing planting structure, achieving both high quality and relatively low price, meeting the diversified needs of residents' nutritional health, have become an important mission to ensure food security in the new era.
(3) Always adhere to the concept of food security: "domestically based and domestically oriented". Strategically, make sure that "the grain is basically self-sufficient and the ration is absolutely safe". The key points are to ensure the basic self-sufficiency of the two main grains of rice and wheat. Other varieties such as soybeans and corn can be fully deployed in both domestic and international markets to ensure supply. In terms of tactics, we must start from two aspects: improving China's comprehensive grain production capacity and ensuring the import capacity of the international market. It is significant to clarify the basic self-sufficiency of food does not mean denying imports. It is necessary to reasonably determine the food self-sufficiency rate and dynamically adjust it.
(4) Strengthening the comprehensive production capacity of grain is an important means of ensuring the level of food self-sufficiency. To this end, we must keep three "red lines": 1.8 billion acres of arable land "red line", 1.6 billion acres of planting area "red line" and 1.4 billion acres of grain planting area "red line." At the same time, focus on protecting and improving the quality of cultivated land; ensuring the interests of farmers who grow grain; ensuring investment in agricultural infrastructure; and implementing science and technology to promote agriculture.
(5) Relying on the "One Belt, One Road" strategy, we will further participate in global food security governance and provide global security for food security. As China's openness to foreign trade continues to increase, the level of food security is increasingly affected by the impact of international agricultural products. To this end, we must coordinate the domestic and international markets and resources to enhance China's agricultural competitiveness, actively participate in global food security governance, and participate in the formulation of agricultural international trade rules. Make better use of international agricultural markets and agricultural resources to effectively adjust and supplement domestic food supplies.

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Scale Development and Validation of Crowd Logistics Risk Control in Chinese Context

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Abstract This paper clarified the concept of crowd logistics risk control and explored its structure in Chinese context. Then, this study designed its primary scale by in-depth interviews and conducted a survey on a sample of crowd drivers who engaged in crowd logistics. Based on the results from Exploratory Factor Analysis and Confirmatory Factor Analysis, this paper defined crowd logistics risk control as a three-dimension construct including "monitor", "motivation" and "online payment". Further, this paper validated the scale in Chinese context by further analysis of reliability and construct validity. An effective instrument for future empirical research in Chinese context is provided by the scale we developed in this study.

Keywords Risk control · Crowd logistics · Scale development · Scale validation

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1 Introduction

Crowd logistics is an infant phenomenon emerging in sharing economy [1]. Crowd logistics allows shippers to outsource their logistics tasks to the casual drivers who have capacities and time through crowd logistics platforms [2]. Crowd logistics has been considered to create economic value, social value and environmental value [3]. Specifically, it contributes to reduced transportation cost, increased logistics efficiency and enhanced logistics quality [3]. However there still exists several risks in crowd logistics, such as drivers' credit risks, transaction risks, lower logistics reliability and so forth, because shippers are not able to fully monitor crowd logistics processes and drivers' operations. Thus, it is significant for mitigating logistics risks to explore the risk control strategies conducted by crowd logistics companies, which provides valuable insights for future development of crowd logistics and enriches crowd logistics literature.

Extant literature has paid much attention to supply chain risk control [4–6], which lays a solid foundation for the risk control literature. However, we have little knowledge on risk control in the crowd logistics context because of the infant nature of crowd logistics. We still need more work to explore how to mitigate crowd logistics risks and clarify the key roles that crowd logistics platforms play in risk control. In order to obtain better understanding of crowd logistics risk control, this paper aims to explore the operational definition of crowd logistics risk control and develop validated scales for it.

This study makes contributions in several aspects. First, this paper adds to crowd logistics literature by specifying the risk control strategies that crowd logistics companies implement in practice. Second, this study developed scales for crowd logistics risks control through in-depth interviews and validated the scales by conducting a survey. Such a scale development research offers other researchers the instrument for future studies. Third, this study offers valuable insights for crowd logistics companies to better monitor drivers and helps crowd logistics companies to improve their risks management.

This paper is organized as follows. Section 2 introduces the literature review and clarifies the concept of crowd logistics risk control. Section 3 presents a detailed research methodology to develop a scale for crowd logistics risk control and validate it. Then, we discuss the implications of this research and provide suggestions for further studies in Sect. 4.

2 Literature Review

According to extant literature, crowd logistics is involved with several risks, which mainly include privacy and security concerns, and delivery delays [7]. For example, crowd drivers uploading documents incorrectly may lead to security concerns and influence the logistics reliability negatively [8]. Besides, the delivery of physical products is involved with the risks of loss, damage and deterioration [8]. Hence, it is significant for crowd logistics companies to take actions to address the risks.

Risk control aims to reduce the risks [4]. Within the context of crowd logistics, scholars have identified several tactics for mitigating risks, such as rigorous selection process, rating systems, personal websites, secure communication channels and secure online payment system [9]. For instance, most companies demand drivers to upload their IDs and conduct strict background checks. If drivers do not meet platform companies' requirements, they will be refused [2]. In addition, crowd logistics companies have established online feedback systems to assess drivers in the form of a star rating [10]. Crowd logistics companies also provide drivers with online training programs to make them informed of policies and laws [10]. Besides, crowd logistics companies provide drivers with convenient channels to encourage direct contacts between shippers and crowd drivers [9]. The online payment system is another mechanism through which crowd logistics platforms mitigate the transaction risks [3]. Consistent with literature, crowd logistics risk control refers to the tactics that crowd logistics companies employ to reduce the risks resulting from crowd drivers' operations and crowd logistics processes.

Even though crowd logistics literature pays attention to the risk control tactics, empirical researches about the consequences and the mechanisms of crowd logistics risk control are still infant. To explore the mechanisms of crowd logistics risk control, the research which aims to develop scales for crowd logistics risk control is needed.

3 Methodology

Referring to the procedures of scale development and validation proposed by Churchill [11], this study employ the following procedures to develop the scale of crowd logistics risk control. First, this paper obtained the open codes reflecting crowd logistics risk control in Chinese context through in-depth interviews. Second, this study screened and categorized the open codes of crowd logistics risk control, and the initial items were formed. Third, the Delphi method was used to evaluate all the items, and the initial scale of crowd logistics risk control in Chinese context was constructed. Fourth, we conducted a large-scale questionnaire survey to explore the scale structure and test the validity of the scale. Finally, a crowd logistics risk control scale in Chinese context with good reliability and validity was formed.

3.1 Questionnaire Compilation

1) *Interview:* In August 2018, we conducted in-depth interviews with nine middle-level or senior-level managers who were familiar with the business model of crowd logistics. They discussed the contents of crowd logistics risk control, thereby helping us understand the specific descriptions of crowd logistics risk

control. After interviews, this paper transcribed the voice recordings of interviews and obtained interview data. In addition, this paper collected archival data such as official website information, blogs, news reports of the interviewed logistics enterprises as a complement to interview data. After the integration of interview data and archival data, we used Nvivo 11.0 for open coding, and obtained 113 initial codes which described crowd logistics risk control.

2) *Items filtering:* Firstly, the group comprising six authors, two professors and one associate professor of management preliminarily screened the open codes above. Specifically, the group deleted the ones that were not in accordance with the concept of crowd logistics risk control, and screened the ambiguous or unclear codes, thus obtaining 91 codes. Then they clustered the 91 codes and classified them into 17 measurement items after discussions and consultations.

Secondly, in order to test the validity of the classification results, three Ph.D. students of management were recruited to evaluate them. The procedures were as follows: At first, three Ph.D. students were trained to understand the meanings of 17 existing items; then, they were asked to make independent judgments on the 91 codes of crowd logistics risk control and divide them into 17 items. Finally, the classification results were collected. There could be four results after the reviews of three students: first, three students and the screening group came up with the same results; second, two of the students obtained the same results as the screening group; third, only one student got the same results as the screening group; four the whole results of the three students were totally different from those of the screening group. After comparisons and discussions, we deleted the codes that appeared in the latter two conditions. Then 78 codes were obtained.

Thirdly, we deleted the items containing only 1–2 codes. Only containing a few codes in an item means that the item is not a common manifestation of crowd logistics risk control. Therefore, we deleted the items that contain less than two codes. Then we obtained 14 items.

3) *Preliminary questionnaire design:* The 14 items were discussed one by one to ensure their accuracy and readability. At the same time, we invited three middle-level managers with more than five years' working experience in crowd logistics companies to check all the items. According to their suggestions, 14 items were compressed into 13 items, and an initial questionnaire of crowd logistics risk control was constructed. In order to improve the availability of data, we selected the drivers, who were using crowd logistics platforms for a long time, as the respondents, and asked them to evaluate the crowd logistics risk control tactics. All the items were measured by a 7-point Likert-type scale (1 = Strongly Disagree, 4 = Neutral, and 7 = Strongly Agree).

3.2 Exploration of Scale Structure

1) *Data collection:* In this study, two crowd logistics enterprises in Shandong Province were selected to issue questionnaires online and offline to the drivers who were using crowd logistics platforms. A total of 265 valid questionnaires were collected, including 101 printed questionnaires and 164 online questionnaires. The number of samples met the requirements of the factor analysis.
2) *Items analysis:* The purpose of items analysis is to test whether the scale can distinguish different levels of subjects' answers. This study ranked each item's scores from high to low, and the top and bottom 25% of each item's scores were selected to form the high and low groups, respectively. The high and low groups of each item's scores were tested by the independent sample T test. If the test results are significant at the 95% confidence level, it shows that the scale can distinguish different levels of subjects' answers and should be retained; otherwise, it should be deleted. The results of item analysis in Table 1 show that all the 13 items in the pre-test questionnaire have good discrimination.
3) *Explorative factor analysis:* Before further validation, the data was randomly divided into two groups, one for exploratory factor analysis ($n = 133$) and the other for confirmatory factor analysis ($n = 132$). The purpose of exploratory factor analysis is to find common factors and to explore the structure of the scale.

   a) *Items purification:* Churchill pointed out that the "garbage items" of the scale should be purified before the factor analysis was carried out, otherwise

Table 1 The results of T test

Item	T test		
	t value	*df*	*Sig.*
Item1	−24.746	130	.000
Item2	−22.781	130	.000
Item3	−22.540	130	.000
Item4	−23.599	130	.000
Item5	−24.716	130	.000
Item6	−19.801	130	.000
Item7	−23.082	130	.000
Item8	−23.894	130	.000
Item9	−22.412	130	.000
Item10	−23.350	130	.000
Item11	−20.919	130	.000
Item12	−28.085	130	.000
Item13	−24.615	130	.000

Table 2 Results of items purification

Item	CITC	Cronbach's α after deleting this item	Cronbach's α
Item1	.589	.914	.918
Item2	.571	.915	
Item3	.595	.914	
Item4	.594	.914	
Item5	.684	.911	
Item6	.633	.913	
Item7	.749	.908	
Item8	.735	.909	
Item9	.689	.911	
Item10	.652	.912	
Item11	.607	.914	
Item12	.635	.913	
Item13	.719	.909	

it would be difficult to accurately identify the dimensions of the items [11]. In this study, CITC value and Cronbach's alpha coefficient were used as the purification criteria for purifying items. When an item satisfies the following two conditions simultaneously, it can be deleted: first, CITC value is less than 0.5; second, Cronbach's alpha coefficient will increase after deleting the item. After this step, we found that the 13 items met the purification standard and could be retained (see Table 2).

b) *Explorative factor analysis:* In order to explore the dimensions of crowd logistics risk control, this study used SPSS 22.0 to conduct exploratory factor analysis on the 13 items. Before conducting exploratory factor analysis, we calculated the KMO. The results showed that the KMO measure of the questionnaire was 0.892. As the KMO measure was greater than the benchmark value of 0.6, it suggested that factor analysis could provide reliable factors [12]. In the process of exploratory factor analysis, common factors were extracted by principal component analysis and maximal rotation of variance. The criteria for items selection are: selecting factors with eigenvalues are greater than 1; the factor loading is greater than 0.4; if the cross-factor loading of an item exceeds 0.4, delete it [13]. According to this criterion, three common factors were extracted, and the cumulative variance contribution rate was 76.253%, which was more than the minimum value of 50% [13]. By conducting EFA, the factor loadings of each item in the scale were attained. The factor loading of each item ranged from 0.757 to 0.873 (see Table 3), which were all greater than the benchmark value of 0.50 and indicated convergent validity [14]. According to the factor analysis, three factors were named as "monitor", "motivation" and "online payment".

Table 3 The results of EFA

Item	Monitor	Motivation	Online payment
Item1	.788		
Item2	.757		
Item3	.854		
Item4	.794		
Item5		.871	
Item6		.842	
Item7		.812	
Item8		.779	
Item9		.873	
Item10			.818
Item11			.870
Item12			.839
Item13			.765

Combined with the literature review and in-depth interviews, we believe that monitor mechanism refers to a series of management measures provided by crowd logistics platforms to supervise and control drivers' behaviors. The monitor mechanism provided by platforms mainly includes GPS navigation systems, video cameras, temperature sensors and other monitoring tools, which can supervise drivers' service processes and monitor the conditions of cargoes. Motivation mechanism refers to a series of measures taken by crowd logistics enterprises to influence crowd logistics drivers under asymmetric information conditions. Specifically, crowd logistics enterprises induce drivers to behave in compliance with shippers' interests by incentives or restrain from opportunistic behaviors by penalty measures [15]. The motivation mechanism mainly includes awards, fines, blacklists and other measures. Online payment mechanism refers to the payment service provided by crowd logistics enterprises in order to ensure the security of payment. This is mainly reflected in the following process. After a shipper makes a payment on the platform, a third-party financial institution will supervise it. After the driver fulfills the logistics task and the recipients confirm it, the driver will receive the payment.

3.3 Confirmative Factor Analysis

In order to ensure that the three-factor model obtained by exploratory factor analysis is optimal, this study used Mplus 7.4 to conduct confirmatory factor analysis on the 13 items. Table 4 shows that the fit indices of the three-factor model are better than those of the single-factor model and the two-factor models. Specifically, we used the comparative fit index (CFI), Tucker-Lewis index (TLI) and root mean square error of approximation index (RMSEA) to evaluate these comparative models. A model

Table 4 The results of comparable models

Model	χ^2	*df*	χ^2/df	CFI	TLI	RMSEA
Single factor	355.237	65	5.465	0.637	0.564	0.184
Two factors[a]	264.445	64	4.132	0.749	0.694	0.154
Two factors[b]	303.513	64	4.742	0.700	0.635	0.168
Two factors[c]	170.676	64	2.667	0.866	0.837	0.112
Three factors	78.000	62	1.258	0.980	0.975	0.044

[a]The model that merges monitor and motivation
[b]The model that merges monitor and online payment
[c]The model that merges motivation and online payment

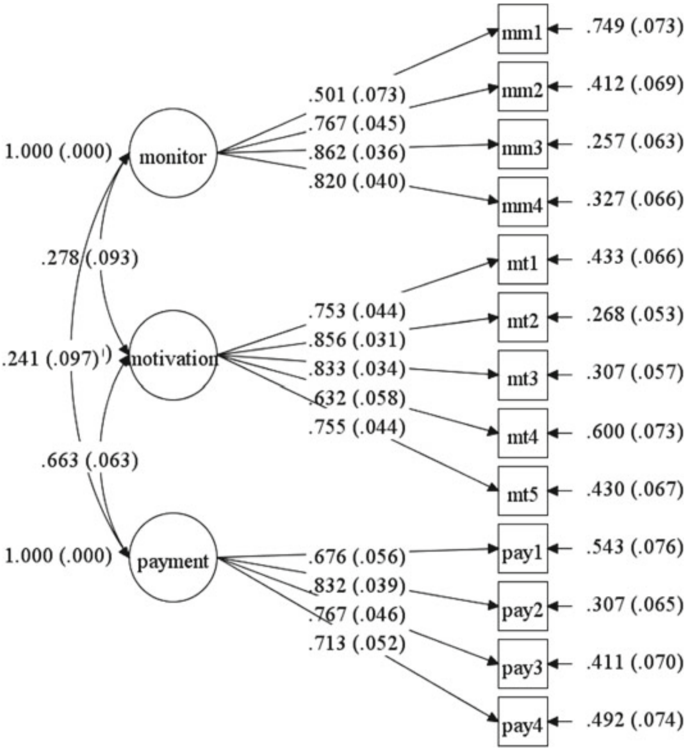

Fig. 1 The structure of the three-factor model

can be considered satisfactory if $\chi^2/df < 3$, CFI > 0.90, RMSEA < 0.08, and TLI > 0.90 [16]. In addition, as shown in Fig. 1, the factor loadings of each item in the three-factor model are between 0.501 and 0.862, which show that each factor has a good explanatory power for each item [16].

Table 5 Reliability analysis

	Monitor	Motivation	Payment	Total items
Cronbach's α	0.827	0.877	0.837	0.864
Number	4	5	4	13

Table 6 Validity analysis

Factor	CR	AVE
Monitor	0.833	0.564
Motivation	0.878	0.593
Payment	0.836	0.561

3.4 Reliability and Validity Analysis of the Scale

1) *Reliability analysis:* In order to evaluate the reliability of the three-factor model of crowd logistics risk control, it is necessary to evaluate the internal consistency of the scale. Generally, we used Cronbach's α coefficient to assess the reliability of the scale. The results in Table 5 show that the Cronbach's α value of the three factors are all greater than the benchmark value of 0.7, which suggest good reliability.
2) *Validity analysis:* We used the combined reliability (CR) and the average extraction variance (AVE) to assess the validity of the scale. The results in Table 6 show that the CR values of the three factors are greater than 0.7, and the AVE values are more than 0.5, which show that the scale has good convergence validity. Meanwhile, the standardized correlation coefficients of the three factors were $P1 = 0.278$, $P2 = 0.241$, $P3 = 0.663$ (see Fig. 1), which were smaller than the square roots of the AVEs (monitoring = 0.751, motivation = 0.770, online payment = 0.749). The results indicated good discriminant validity. It can be concluded that the scale developed in this study has good construct validity.

4 Discussion

4.1 Results and Implications

This study specified the connotation of crowd logistics risk control, explored its structure, developed and validated the scale of crowd logistics risk control in Chinese context. The results show that: first, the scale of crowd logistics risk control consists of three dimensions, namely "monitor", "motivation" and "online payment". Second, following the Churchill's procedure of scale development and validation, this study concluded the scale had good reliability and validity in Chinese context.

The conclusion of this study has certain theoretical significance and practical implications for the research of crowd logistics risk control. The theoretical significance lies two aspects. First, this study specifies crowd logistics the concept and the structure of crowd logistics risk control, which enriches the theoretical literature of crowd logistics. Second, this paper developed a validated scale for crowd logistics risk control, which lays a foundation for further empirical research on risk control within the context of crowd logistics.

This paper also provides practical implications for future development of crowd logistics companies. First, crowd logistics companies can use this scale to assess the status of their risk control strategies to improve the effectiveness of risk management. Second, crowd logistics companies need to pay attention to risk control for future development, especially to the monitor, motivation and online payment mechanisms. Third, advanced technologies such as GPS devices and temperature sensors need to be used to monitor drivers' operations. It's also necessary for crowd logistics companies to use machine learning algorithms to assess drivers' performance. Finally, crowd logistics companies need to construct online payment systems to ensure financial security and mitigate financial risks for drivers and shippers.

4.2 Limitation and Future Research

This study still has some limitations. First, this study didn't conduct nationwide surveys because of the constraints on time, energy and social resources. Therefore, it is still necessary to verify the generality in other cultural background. Second, the data of this study was provided by the drivers involving in crowd logistics. Although the drivers have knowledge of crowd logistics risk control tactics, the data they reported was still narrow. Future studies can involve the managers of crowd logistics companies as the respondents to ensure the generality of the data.

5 Conclusion

Our study specified the contents and the structure of crowd logistics risk control. Based on this, we developed and validated the operational scale of crowd logistics risk control. This study laid a solid foundation for further empirical research by providing a validated instrument and offered valuable insights for management practices. Our study offers broad avenues for future researches to enrich the crowd logistics literature.

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The Empirical Analysis of Cultural Products Circulation Affects Cultural Industry Security in China

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Abstract Under the background of globalization, developing the circulation of cultural products has become an important channel to enhance the competitiveness of cultural industry for a country. The cultural industrial competitiveness is the important part of cultural industry security, therefore, the study on the influence of cultural product circulation on the cultural industry security, has great theoretical and practical significance. Based on the theory of industrial security, to build the evaluation system of cultural industry security, and analyze the relationship between cultural products circulation and cultural industry security using the factor analysis and linear regression analysis, the results show that there is a positive correlation.

Keywords Cultural products circulation · Cultural industry security · Empirical analysis

1 Introduction

Internationally, the change of the competitive environment in the world makes the competition of comprehensive national strength of one country no more than dominated by the competition of "hard power" such an military equipment, economic strength and scientific and technological creation, but pays more attention to the competition of "soft power" like knowledge innovation, influence of values

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and cultural consumption. The cultural industry is regarded as a kind of cultural "soft power", is transforming the traditional national security concept rapidly and profoundly by its intangible influence and extensive penetration. Many countries on abroad put into sharp focus on cultural products circulation, for example, the box-office juggernaut of Hollywood movies. The cultural industry is still in the initial stage of development in China, international competition is obviously inadequate with developed countries, and the cultural products circulation has not drawn enough scholarly attention. Therefore, it is necessary to find one impetus for the cultural industry security by figuring out the influence relation exists between cultural products circulation and cultural industry security.

2 The Establishment of Evaluation Index System of Cultural Industry Security

Based on the five principles of scientific, comprehensive, comparability, operational and model principle, this paper designed and established the evaluation index system of cultural industry security. According to the industrial safety theory, cultural industry security is not just cultural industry protection, but more crucial is to promote the competitive strength of cultural industry. Considering the influencing factors composition of industry safety, and combining the characteristics and influencing factors of cultural industry security, this article determines the second class evaluation index of cultural industry security from four different aspects of cultural industry: domestic environment, controlling power, competitive power and the dependence of foreign countries.

2.1 Domestic Environment Index of Cultural Industry Security

In the industrial safety theory, the major indexes of the domestic environmental include financial environment, production factor environment, market demand environment and industrial policy environment. And on this basis, referring to the characters and affecting factors of cultural industry safety, this paper uses the currency exchange cost to express the index of financial environment, and express the index of factor environment by labor quality, market demand index by domestic market demand and per-capita cultural consumption, policy environment by the ratio of cultural operating expenses and the investing and financing environment, development of cultural industry by innovation index of cultural industry.

2.2 Competitive Power Index of Cultural Industry Security

Cultural industry competitiveness is the ability of cultural industry to maintain its own development, and also is a kind of defensive ability to resist the invasion of foreign cultural, which consists of domestic market share, trade competitiveness index, industrial concentration, industrial R&D costs and domestic competitiveness. This paper reflects the competitiveness of cultural industry from six aspects: the proportion of added value of cultural industry to GDP, domestic market share, international market share, foreign trade index, indicative comparative advantage index and industrial R&D cost.

2.3 Dependence Indexes of Cultural Industry Security

The dependence on cultural industry reflects is the degree of dependence on foreign market for cultural industry in China. With the development of foreign trade, the external dependence of china's cultural industry can be mainly measured from three aspects: export dependence, import dependence and capital dependence.

2.4 Controlling Power Index of Cultural Industry Security

It is the key for controlling power of cultural industry that how and what extent it will be controlled by foreign capital, which includes control in market, technology, equity, policy-decision right, brand, etc. On the basis of data availability, this article chooses two indexes to measure, that are the market control rate of foreign capital and foreign capital assets rate in fixed-assets investment.

3 Evaluation Method and Data Acquisition

At present, the comprehensive evaluation of cultural industry security is far from maturity, and the evaluation method of subjective weight is greatly interfered by human factor. This article adopts factor analysis method to make the evaluation aim at making the evaluation results relatively objective and better close to the actual situation.

Data acquisition methods are as follows:

1) *costs in terms of foreign exchange:* is measured by the average annual price of the RMB exchange rate. Data from: the official website of the Foreign Exchange Administration.
2) *Quality of labor:* is measured by the ratio of the average wage of labor force in cultural industry to the national's.. This paper uses the ratio of the average wage of the employed people in cultural, sports and entertainment to the total population's in cities and towns. Data from China Statistical Yearbook.
3) *Domestic market demand:* is measured by per capita disposable income of urban residents. Data from China Statistical Yearbook.
4) *Per capita cultural consumption expenditure:* is measured by the proportion of per capita consumption expenditure of urban residents in cultural, education and entertainment to the total population's urban. Data from China Statistical Yearbook.
5) *Investment and financing environment:* measured by the ratio of growth rate of fixed assets investment in cultural, sports and entertainment in china [1].
6) *Policy factors:* Some scholars express it in terms of the proportion of fiscal expenditure to GDP [2],which value is also measured through cultural, entertainment and sports together. Data from China Fiscal Yearbook.
7) *Innovation of cultural industry:* is expressed by the proportion of industrial R&D expenditure in national's, and is measured by the ratio of R&D internal expenditure in cultural, entertainment and research and development institutions to nationwide. Data from China Science and Technology Statistical Yearbook.
8) *Domestic market share:* is expressed by the ratio of cultural industry output value to GDP. Data from Statistical Yearbook of Chinese Cultural and Related Industries, and adjust the data change coefficient to avoid the impact of statistical caliber inconsistency.
9) *Domestic market share:* is measured by the ratio of output minus export of cultural industry to output minus export plus import. Data from: Yearbook of Chinese Culture and Related Industry, International Trade and Development Conference Database.
10) *International market share of cultural industry:* is expressed by the export of cultural industry the share of total world's data from the Chinese Culture and Related Industries Yearbook, 2017.
11) *Industrial Trade Competitiveness Index:* is measured by the ratio of net export of culture products to total import and export of cultural industry. Data source are the same as last one.
12) *Indicative comparative advantage index:* is expressed by the ratio of export proportion of Chinese cultural products to international trade in cultural products. Data from international trade and development conference database.

13) *The R&D expenses of cultural industry:* is measured by the internal cost sum of scientific and technological research in various cultural industries. Data from the summary of china science and technology statistics yearbook from 2006–2017.
14) *External dependent of import and export:* is measured by the ratio of import/export of cultural industry to total output value of cultural industry.
15) *External dependence of foreign capital:* some scholars use the ratio of industrial foreign investment to total industrial investment to measure [3]. This paper uses the ratio of foreign investment to total investment in cultural industries to describe. Data from China Statistical Yearbook.
16) *Market control power of foreign capital:* is described by cultural industry's domestic market share.
17) *Investment control of foreign fixed assets:* is measured by the proportion of foreign investment in fixed assets of cultural, sports and entertainments.

4 Empirical Evaluation and Analysis of Cultural Industry Safety

4.1 Exploratory Analysis

Exploratory analysis is also called feasibility test, which main function is to determine the applicability of the index system to factor analysis. KMO (Kaiser-Meyer-Olkin) and Bartlett tests are used here. The test results are shown as follows (Tables 1, 2, 3 and 4).

Table 1 Examination of KMO and Bartlett in cultural industry environment

Test of KMO and Bartlett		
Kaiser-Meyer-Olkin measure of sampling sufficiency		0.775
Bartlett sphericity test	Approximate chi-square	72.653
	df	21
	Sig.	0.000

Table 2 KMO and Bartlett's test of cultural industry competitiveness

Test of KMO and Bartlett		
Kaiser-Meyer-Olkin measure of sampling sufficiency		0.577
Bartlett sphericity test	Approximate chi-square	83.993
	df	15
	Sig.	0.000

Table 3 KMO and Bartlett test of cultural industry's external dependence

Test of KMO and Bartlett		
Kaiser-Meyer-Olkin measure of sampling sufficiency		0.722
Bartlett sphericity test	Approximate chi-square	18.945
	df	3
	Sig.	0.008

Table 4 KMO and Bartlett test of foreign investment control rate in cultural industry

Test of KMO and Bartlett		
Kaiser-Meyer-Olkin measure of sampling sufficiency		0.500
Bartlett sphericity test	Approximate chi-square	110.951
	df	1
	Sig.	0.000

From the above test results, the KMO values of the four dimensions of cultural industry security are larger and the P values tested are less than the significant level of 0.05. therefore, zero hypothesis is rejected, which indicates that factor analysis is suitable.

4.2 Evaluation Based on Factor Analysis

The essence of factor analysis is to extract several common factors from the multi-index system of the object of study, and to evaluate the object of study by the score of common factors.

Step one, factor analysis model is established and expressed as follows: $X = AF + \varepsilon$.

In which, $X = (x_1, x_2, \Lambda, x_p)^T$,

$$F = (f_1, f_2, \cdots, f_q)^T,\ \varepsilon = (\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_p)^T$$

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1q} \\ a_{21} & a_{22} & \cdots & a_{2q} \\ \cdots & \cdots & \cdots & \cdots \\ a_{p1} & a_{p2} & \cdots & a_{pq} \end{bmatrix}$$

Xi is a standardized index, F is the common factor with a mean of 0 and a standard deviation of 1, and there is no correlation between F1, q < p. ε is the special factor with a mean value is 0, and standard deviation is 1, ε_i is not correlated with each other. F is independent of each other, A is the factor load matrix.

Step two, to obtain the factor scoring model:

$$f_i = \beta_i X$$

β_i is the factor score coefficient vector,

$$\beta_i = (\beta_{1i}, \beta_{2i}, \cdots, \beta_{pi})$$

And then get the comprehensive evaluation model:

$$\lambda_i = \omega_i F$$

Step three, taking the proportion of the eigenvalues corresponding to each principal component to the sum of the total eigenvalues of the principal component as the weight ω_i, to obtain the comprehensive score, λ_i represents the comprehensive score of i year.

4.3 Extraction of Common Factor

The number of common factor is determined according to the magnitude of eigenvalues and the cumulative contribution rate of common factors. Standardized processing and factor analysis of secondary index data of cultural industry safety are carried out to obtain the value of the analysis process. As shown in Table 5, the cumulative contribution rate of variance is selected as four principal components, and the cumulative contribution rate of variance is 91.985%, which means that the extracted common factor covers 91.985% of the information, and the extraction effect is remarkable.

Next, the weight of each index is calculated according to the component matrix of Table 6.

Normalization of absolute loads for different variables:

$$A_{ij} = \frac{|\alpha_{ij}|}{\sum_{i=1}^{18} |\alpha_{ij}|}$$

For each variable, the weight of each variable is calculated by summing up its load proportion under different factors.

$$B_{ij} = \sum_{j=1}^{4} A_{ij}$$

The weight of each variable is obtained by normalizing the weight of each variable.

$$W_i = \frac{B_i}{\sum_{i=1}^{18} B_i}$$

Table 5 Cumulative contribution rate of variance

Total variance of interpretation						
Ingredients	Initial eigenvalue			Extract square sum loading		
	Total	Variance %	Cumulation %	Total	Variance %	Cumulation %
1	12.479	69.325	69.325	12.479	69.325	69.325
2	1.909	10.606	79.932	1.909	10.606	79.932
3	1.425	7.919	87.851	1.425	7.919	87.851
4	0.744	4.134	91.985	0.744	4.134	91.985
5	0.534	2.965	94.950			
6	0.344	1.910	96.859			
7	0.255	1.419	98.279			
8	0.206	1.145	99.424			
9	0.064	0.357	99.781			
10	0.035	0.193	99.974			
11	0.005	0.026	100.000			
12	4.579E−016	2.544E−015	100.000			
13	2.017E−016	1.121E−015	100.000			
14	1.551E−016	8.616E−016	100.000			
15	6.242E−017	3.468E−016	100.000			
16	2.233E−017	1.240E−016	100.000			
17	−4.149E−018	−2.305E−017	100.000			
18	−8.510E−017	−4.728E−016	100.000			

[a]Extraction method: principal component analysis

From the weight distribution values of safety indicators of cultural industry in Table 7, it can be found that the indicators affected by the circulation of cultural products have a higher weight. Among the 18 third indicators of cultural industry security, the proportion of cultural entertainment consumption is the highest, which means it has a greater impact on the safety of cultural industry, and consumers' consumption of cultural products is linked by circulation, the faster and more accurate the advertising and logistics demand information of cultural products to consumer. Insides, other indicators, such as the international market share of the industry and the trade competition index of the industry, the higher the circulation efficiency, the higher the value of these indicators.

According to the weight and dimensionless variable value, the safety value of cultural industry from 2005 to 2016 is obtained, as shown in Fig. 1.

From the trend chart of cultural industry security, we can see that the cultural industry is basically in a safe state, but the degree of security is not high in China.

Table 6 Component matrix

	Ingredients			
	1	2	3	4
Costs in terms of foreign exchange	0.792	0.400	0.192	0.366
Labor quality	−0.965	0.168	0.174	0.055
Per-capita disposable income	0.860	0.006	0.165	−0.005
Proportion of cultural and entertainment consumption	−0.006	−0.564	−0.625	0.485
Growth rate of fixed asset investment	0.747	0.089	0.309	0.199
Proportion of cultural expenditure in financial expenditure	−0.871	0.062	0.018	0.358
Cultural industry R&D expenditure/national R&D total expenditure	−0.923	0.248	0.256	0.094
Proportion of added value of cultural industry to GDP	−0.912	−0.013	0.327	0.148
International market share of industry	0.845	0.390	−0.080	0.194
Foreign trade index	−0.814	−0.340	0.428	0.088
Indicative comparative advantage index	−0.909	0.257	0.184	0.236
R&D expenses	0.940	−0.075	−0.075	0.070
Domestic market share	0.520	0.796	−0.250	0.085
Import dependence	0.672	−0.570	0.276	0.208
Export dependence	−0.904	0.148	−0.270	0.099
Capital dependence	0.940	−0.075	−0.075	0.070
Foreign capital control rate	−0.914	0.048	−0.336	−0.028
Control rate of investment in foreign fixed assets	0.914	−0.048	0.336	0.028
Method of extraction: principal component				
[a]four components have been extracted				

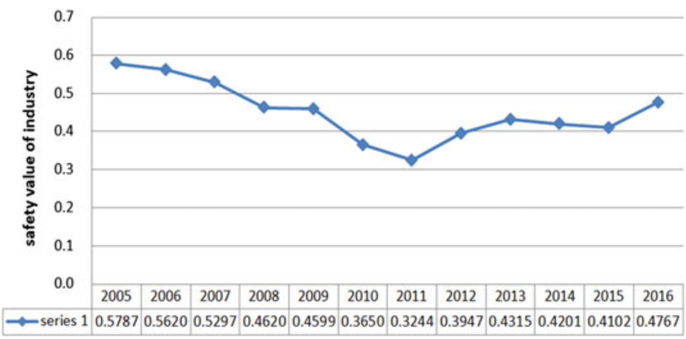

Fig. 1 Safety value of cultural industry

Table 7 Weight distribution of cultural industry safety index system

Secondary indexes	Third indexes	Third indexes weight (%)
Industrial environment (42%)	Costs in terms of foreign exchange	8.04
	Labor quality	4.13
	Domestic market demand	2.51
	The proportion of cultural and entertainment consumption	11.17
	Investment and financing environment	5.35
	Policy factors	5.15
	Innovative power of cultural industry	5.34
Industrial competitiveness (34%)	Industrial domestic market share	4.84
	Domestic market share	5.92
	International market share of industry	6.61
	Industrial trade competitiveness index	6.21
	Indicative comparative advantage index	3.11
	Industrial R&D expenses	7.71
External dependence (16%)	External dependence of imports	7.90
	Export external dependence	4.85
	External dependence of capital	3.11
Foreign investment control rate (8%)	Foreign capital market control rate	4.02
	Control rate of investment in foreign fixed assets	4.03

5 Analysis of the Impact of Cultural Products Circulation on the Safety of Cultural Industry

5.1 Selection of Circulation Index of Cultural Products

Based on summarizing the index system of circulation industry established by previous scholars [4–7], it is found that the statistical indicators used in high frequency include: circulation scale index, circulation structure index, circulation operation performance index. However, these indicators are only part of the information technology of circulation, and cannot represent the "soft power" of the cultural products. As the above analysis shows, the higher the degree of informatization, the easier it will be for foreign cultural products to enter the Chinese market, which will also be a threat to china's cultural industry.

Based on this reality, this paper chooses the trade index of cultural content products to represent the circulation index of cultural products, and measure it by the ratio of net export to the total volume of national trade, and uses the sum of import data and export data of books, periodicals, newspapers, audio-visual products, electronic and digital publications, television, movies, represents the total import and export volume of cultural industry trade respectively.

Specific data are shown in Table 8 below:

5.2 *Impact Analysis of the Cultural Products Circulation on the Safety of Cultural Industry*

In order to describe the impact of cultural product circulation on the safety of cultural industry, this paper chooses the trade index of cultural products as an independent variable, and the safety value of cultural industry as the dependent variable to make a simple linear regression analysis. The results are shown in Table 9.

The regression results show that the resolvable coefficient of the model is 0.413, which indicates that there is a positive correlation between the two variables. The correlation coefficient is 0.643, which indicates that the change of product circulation represented by the trade competitiveness of cultural content products will cause a change of 0.643% points in the safety degree of cultural industry.

Table 8 Index value of cultural products circulation

Year	2005	2006	2007	2008	2009	2010
Circulation index value	−0.13338	−0.15048	−0.22887	−0.22102	−0.28686	−0.32562
Year	2011	2012	2013	2014	2015	2016
Circulation index value	−0.59135	−0.77363	−0.73142	−0.70512	−0.66881	−0.66862

[a]Data sources: china cultural industry yearbook 2014 and china culture and related industries yearbook 2017, china industrial information network and the official website of the state administration of press and publication

Table 9 Model summary

Model	R	R^2	Adjust R^2	Error of standard estimation
1	0.643a	0.413	0.355	0.0618778

[a]forecasting variables: (constant), content products trade index

Table 10 Variance analysis results

Model		Sum of squares	df	Mean square	F	Sig.
1	regression	0.027	1	0.027	7.044	0.024b
	residual	0.038	10	0.004		
	total	0.065	11			

[a]dependent variable: factor analysis of industrial safety value

[b]forecasting variables(constant), content product trade index.

Table 11 Analysis results of cultural products trade index on cultural industry safety

Model	Non-standardization coefficient		t	Sig.
	B	Standard error		
(Constant)	.541	.038	14.132	.000
Content product trade index	.197	.074	2.654	.024

5.3 Significance Test

The significance of the regression equation as a whole is tested. The results are shown in Table 10.

From the results of variance analysis showed that the P value if F statistic is less than the significant level $\alpha = 0.05$, which indicated that the regression equation is significant as a whole.

5.4 Regression Analysis Cultural Products Trade Index on Cultural Industry Safety

The results of regression analysis as follows (Table 11):

From the above regression results, we can see that the regression equation is significant as a whole, and the trade index of cultural content products has an obvious positive impact on the safety of cultural industry. That means, the circulation of cultural products is an important factor affecting the safety of cultural industry. Promoting the circulation of cultural products has an important positive role in maintaining the safety of cultural industry.

Therefore, it is a reasonable choice to pay attention to the circulation of cultural products strategically and regard it as the basic path for the transformation of the development mode, structural adjustment and industrial upgrading of cultural industry security. There are some necessary paths to make cultural product circulation as an engine of cultural industry safety, such as establishing the concept of circulation of cultural products and legal environment, deepening the reform of circulation system. Using internet thinking to create a diversified platform, integrating technology and data to enhance user experience, developing relational marketing to form a new diversified marketing trend, and speeding up the training of talents and promoting the strategy of "going out" of cultural products.

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Using Factor Analysis to Evaluate the Classification Reform Result of State-Owned Geological Exploration Units

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Abstract When Chinese state-owned geological exploration units are undergoing classification reform, the key to success is to identify the right direction of reform through proper categorization. While such reform is often affected by random application and administrative order, the development capability of geological exploration units lacks sufficient scientific evaluation, which reduces the accuracy of classification reform. As the pure competitiveness theory fails to accurately evaluate the development capability of geological exploration units, this work constructs different development capability evaluation index systems for three types of state-owned geological exploration units, and uses factor analysis to calculate the development capability of sixty state-owned geological exploration units. The evaluation index system of development capability constructed in this paper is specially set for different types of geological exploration units with different natures, which provides a new evaluation method for the classification reform of state-owned geological exploration units.

Keywords Geological exploration units · Classification reform · Development capability · Factor analysis

1 Introduction

Marketization of Chinese geological exploration units classification reform as the key part of sustainable development in the field of global geological exploration, is an effective way to direct successfully transformation of the unclassified units by assessing the development capability of geological exploration units that have completed the classification. However, the problem is that no acceptable evaluation

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model is available to evaluate the development capability of geological exploration units that have completed classification. Chinese geological exploration industry refers to the organizational structure system of units or individuals that are owned by the state to engage in geological exploration industry, of which the geological exploration unit is an effective part. However, after the peak of "golden decade", and then the painful period of geological exploration industry transformation, geological exploration units finally enter the period of repeated fluctuations of classification reform. Chinese geological exploration economic market is a semi-planned economic system under the leadership of the government, which lacks market competitiveness. Among them, geological exploration units are faced with problems such as unclear classification of state-owned geological exploration, non-separation between businesses and enterprises, and serious separation from market economy. In order to ensure the steady development of geological exploration industry, the Central Committee of the Communist Party of China and the State Council issued the "Guiding Opinions of the Central Committee of the Communist Party of China and the State Council on the Reform of Classified Initiatives" ([2011] No. 5). According to the opinions, the geological exploration institutions will complete the classification of public institutions around 2015. The current classification reform of geological exploration units has entered the final closing stage, but there is still no clear classification reform evaluation system to guide the provincial geological exploration units to carry out classification reform.

It is an effective way to construct an evaluation system to evaluate the development capability of geological exploration units that have been classified and to guide the reform of unclassified units. However, most current researches on the classification reform of geological exploration industry are focused on qualitative analysis or the development of state-owned geological exploration units from the core competitiveness of geological exploration units. Such as, Xu believed that the core competitiveness of geological exploration units mainly comes from the ability of geological science, technology and technological innovation [1]. Cao thought that geological exploration units should construct their industrial pattern through the integration of internal resources, integration of external resources and establishment of industrial cluster of geological exploration industry, modern publicity platform to create a service brand, and innovation, to promote the benign development of geological exploration units and to enhance the core competitiveness [2]. Li proposed that the improvement of the core competitiveness of geological exploration enterprises should be reflected in the high unity of talents, prospecting achievements and benefits [3].

However, the above research lacks the following contents: (1) At present, there are 1,117 state-owned geological exploration institutions in China, which are divided into centrally different types according to their management attributes. How construct different evaluation systems for various types to quantitatively analyze development capability? (2) How integrate the current interpretation of the core competitiveness of these geological exploration units and construct a unified standard for the evaluation of the development capability of state-owned geological exploration units? (3) How guide the classified reform and development of geological exploration units through such kind of evaluation?

Since the quantitative analysis of the development capability of geological exploration units and the unified evaluation standard play different roles in the evaluation method, only jointly investigating the evaluation model design and case verification experiment respectively can reveal the truth of the optimal path of the classification reform. In the previous study, domestic and foreign scholars are mostly focused on the rationality and qualitative analysis of the index system setting, such as Porter model and Boston matrix. This type of model only provides the list of components of development capability, which is difficult to describe the strength of development capability in a quantitative way, and systematically evaluate the strength of development capability. With more and more attention paid to the evaluation of development capability, some domestic scholars began to explore the quantitative analysis method of evaluation of enterprise development capability. Such as Cui used principal component analysis to evaluate the sustainable development of Chinese enterprises by constructing a set of enterprise sustainable development evaluation index system [4]. In this research, the factor analysis method is adopted, and different evaluation systems are set up for different geological exploration units. Then, starting from the most superficial and perceptible attributes, these internal attributes and factors are gradually deepened, and the development capability indicator system is constructed by classification [5]. This index system directly shows the development and competition results of the three types of state-owned geological exploration units through quantitative analysis.

This work focuses on the transformation of geological exploration enterprises under the specific national conditions of China and seeks for a new development capability evaluation theoretical model, so as to provide research ideas for solving the core problems of the career classification reform of Chinese geological exploration industry. Among them, (1) the factor analysis method is adopted to analyze the development capability of state-owned geological exploration units, and the development capability index system is constructed for different types of geological exploration units respectively. The quantitative analysis intuitively indicates the strength of the development capability of the three types of state-owned geological exploration units. (2) uniform standard, factor analysis and evaluation method are used to obtain the development capability value; through the comparison of strength and weakness, it is directly reflect the effect of the classification reform of geological exploration units and the development potential of various geological exploration units; (3) sample data are included the development capability index data of sixty state-owned geological exploration units from Beijing, Tianjin, Hebei and Shanxi provinces. It clarifies the direction of the classification reform of Chinese geological exploration industry and guides the classification reform of Chinese state-owned geological exploration units in the next step.

2 Theoretical Basis

2.1 Framework

A scientific and feasible evaluation index system is designed by the following principles: theoretical analysis, expert design, questionnaire survey, most choose, use and continuous improve. The evaluation index of development capability of state-owned geological exploration units is constructed as follows: Firstly, theoretical analysis is carried out based on the analysis of economics and the study of management, and the first-level indicator of state-owned geological exploration units' index system is designed. Then, the significance of indicators and the setting of indicator standards are judged by consulting expert opinions in the form of questionnaire. In other words, the principle of majority selection is adopted to select specific second-level indicators. The objects of the questionnaire survey are targeted, and the people with the most theoretical basis and practical experience are allowed to express the connotation and composition factors of the development capability of state-owned geological exploration units, so that the formation process of indicator system has procedural rationality. The index system selected in the above way is relatively open, which can be constantly improved through the application, trial and error, and running in the evaluation process. In short, the principle of selecting the development capability indicators of state-owned geological exploration units is the first-class and the second-class geological exploration units according to the performance evaluation theory of the institution, and the business-class geological exploration units select the evaluation indicators according to the enterprise capability theory. Along the two clues, one is experts and scholars through the theoretical analysis to the architecture development capability evaluation index system of the basic framework, and the other is to use the questionnaire survey method of the target audience of experience together, that is, from the combination of scientific theory and practical experience on selection to determine what kind of indicators better suited to evaluate these state-owned geological exploration units [6].

2.2 Evaluation Theory

(1) *Performance evaluation theory of state-owned institutions*

At present, there are two opinions about the performance appraisal of state-owned geological exploration units. The one is the performance evaluation method of general public institutions. According to the requirements of performance management system of the ministry of finance, each institution has established a set of unit performance index evaluation system. Generally, the geological institutions establish performance evaluation system for the unit to evaluate development planning goals, the competent department requirements, the completion of the annual key work situation, the ideological and political leadership, and the construction of talent team. The evaluation system is quite necessary, and also is the effective reflection of a business unit to perform business functions, to promote the social state-owned product quality, economic sustainable and healthy development.

Secondly, geological institutions apply for department budgets according to their business development plans, but it is necessary to establish an evaluation mechanism to determine whether the implementation of department budget has achieved the strategic objectives set by the unit, whether the special financial funds have been used and the budget has been falsely reported. Fiscal expenditure performance evaluation refers to use scientific and reasonable performance evaluation indicators to evaluate the efficiency of fiscal expenditure by the financial department and budget department. According to government policy, state-owned institution should establish performance goal, by means of the performance evaluation, so as to improve the budget management, optimize the allocation of resources, control the cost, and improve the quality of state-owned service [7].

(2) *Enterprise capability theory*

At present, the basic theories of enterprise development capability evaluation mainly include general enterprise capability structure theory, enterprise potential factor structure theory, enterprise vitality structure theory and enterprise development strategy capability structure theory.

According to the general capability theory, the capability system of an enterprise includes two aspects: component capability and architecture capability. From the knowledge characteristics of capability, component capability refers to element knowledge, which refers to the components (such as environment, subsidiaries, functions, technologies, etc.) at all levels involved in the enterprise, which is the basic element of enterprise capability. Architectural competence is the knowledge of architecture, including the relationship between components and capabilities at various levels.

Based to the enterprise potential factor structure theory, enterprise development is a process of releasing and giving full play to its potential. According to this model, enterprise development potential exists in the coupling relationship of market, resource and capability. The development of enterprises is faced with market constraints, resource and capacity constraints.

Based to the enterprise vitality structure theory, the "character" of an enterprise has three basic levels as a unique social life form, namely "survival", "growth" and "regeneration". Therefore, the above three characteristics of enterprise vitality can also be regarded as three forces, which is viability, growth and reproduction. They are the basic components of enterprise vitality and the three basic factors determining enterprise vitality. The vitality of an enterprise at any moment is manifested in three aspects: viability, growth capability and regeneration capability. The three abilities comprehensively reflect the vitality of an enterprise [8].

The above-mentioned theory only proposes the capacity composition model of enterprise development from one aspect. The factor theory, the vitality theory and strategic competence only focused on the corresponding following parts: the influence factors of development, how to ensure the vitality and strategic ability of the enterprise, the strategic capabilities of enterprise development. They all have certain rationality, but not comprehensive. They could not analyze the characteristics and structure of enterprise development capability with consideration of future and integrity. To select the components of enterprise development capability evaluation, it is necessary to use relatively comprehensive evaluation indexes as much as possible, to show the enterprise's competitiveness in the market, which is the obvious characteristic of enterprise competitiveness.

3 Evaluation System

3.1 Development Capability Evaluation System for First-Class State-Owned Geological Exploration Units

First-class state-owned institutions refer to those that are involved in national security, state-owned security, state-owned health, state-owned culture, economic & social order and basic civil rights, which must be guaranteed by the government, those that cannot or should not be allocated resources by the market, and those that only provide support and guarantee for the government. The purpose and scope of business of such units should be determined and strictly supervised by the government, and they should not engage in business activities. The core characteristics of first-class state-owned geological exploration units are mainly reflected in the state-owned welfare service ability, which needs to construct the evaluation system of development capability from four aspects: geological work capability, talent team capability, technical equipment capability and economic management capability. The development capability evaluation system for first-class state-owned geological exploration units is shown in Table 1 below.

3.2 Development Capability Evaluation System for Second-Class State-Owned Geological Exploration Units

Second-class state-owned geological exploration units refer to those that provide state-owned services to the whole society that are related to the general needs of the society, which are supported by the government and can be partially realized by

Table 1 Development capability evaluation system for first-class state-owned geological exploration units

Level indicators	The secondary indicators	Index to explain
Geological work capability	The geological achievements	The number of state-owned geological work projects in the past three years
	Quality of work	Project excellence rate
	Physical workload	Physical workload completion rate
	Report concurrent	Whether the remittance report is timely according to regulations
Talent team capability	Proportion of active staff	Total number of staff and workers in service to total number of staff and workers at the end of the period (including retirees)
	Proportion of professional and technical personnel	Total number of professional and technical staff at the end of the term to on-the-job staff and workers
	Proportion of senior titles	Middle and senior staff to total number of employees
	Growth rate of technicians at the end of the year	Annual increase of technicians to total number of technicians at the end of last year
	Technical progress awards	Technical progress award level and quantity
Technical equipment capability	Net technical equipment per capita	Ratio of net equipment value to active employees
	The coefficient of newness	The ratio of net equipment value to original value
	Annual growth rate of equipment assets	Annual growth of equipment assets to total equipment assets at the end of last year
Economic management capability	Department budget assessment	Budget implementation rate
	Management of state-owned assets	Asset-liability ratio

market allocation of resources, as well as those that mainly provide support and guarantee for the government to perform its functions. Such units should carry out activities in accordance with their state-owned welfare objectives and relevant standards set by the state. On the premise of ensuring the realization of state-owned welfare objectives, they may carry out relevant business activities according to law, and the operating income obtained according to law should be mainly used for the development of state-owned welfare undertakings. The core characteristics of second-class state-owned geological exploration units mainly reflect the state-owned welfare service ability and market operation activities, so it is necessary to evaluate their geological work capability, social service capability, talent team capability, technical equipment capability, management capability and leadership team capability [9].

The development capability of second-class state-owned geological exploration units increases their profitability on the basis of giving consideration to state-owned welfare. Therefore, the development capability index system of second-class state-owned geological exploration units includes four first-level indexes, namely, geological work capability, talent team capability, technical equipment capability and management capability. The development capability evaluation system for second-class state-owned geological exploration units is shown in Table 2.

3.3 Development Capability Evaluation System for Business-Class State-Owned Geological Exploration Units

Business-class state-owned geological exploration units refer to state-owned institutions engaged in production and operation service activities, which have been realized or can be realized by market allocation of resources after adjustment. Their reform direction is to be transformed into enterprises. The characteristic of business-class state-owned geological exploration units in the new period is market operation ability.

Because the development capability of business-class state-owned units is the core competitiveness of enterprises, the components of core competitiveness are also the components of enterprise development capability. The core competitiveness of an enterprise is the combination of technology, management and organizational learning. Therefore, the index system of development capability of business-class state-owned geological exploration units is mainly composed of talent competition, innovation ability, operation ability and enterprise culture. The development capability evaluation system for business-class state-owned geological exploration units is shown in Table 3 below.

4 Model and Data

The essence of factor analysis method is to study the relationship among the elements in the correlation matrix. As a multivariable statistical analysis method, its main operation process is to transform the variables with messy relations into a few comprehensive factors with a small number. The basic idea is to group variables into groups that have a high correlation with each other, as well as groups that have a low correlation with each other. The variables that represent the basic structure are called common

Table 2 Development capability evaluation system for second-class state-owned geological exploration units

Level indicators	The secondary indicators	Index to explain
Geological work capability	The geological achievements	The number of state-owned geological work projects in the past three years
	Quality of work	Project excellence rate
	Physical workload	Physical workload completion rate
	Report concurrent	Whether the remittance report is timely according to regulations
	State-owned geological workload	The number of geological projects for state-owned welfare
Talent team capability	Proportion of active staff	Total number of workers in service to total number of workers at the end of the period (including retirees)
	Proportion of professional and technical personnel	Total number of professional and technical staff at the end of the term to on-the-job staff
	Proportion of senior titles	Middle and senior staff to total number of employees
	Growth rate of technicians at the end of the year	Annual increase of technicians to total number of technicians at the end of last year
	Technical progress awards	The number of technical progress awards
Technical equipment capability	Net technical equipment per capita	Ratio of net equipment value to active employees
	The coefficients of the new	The ratio of net equipment value to original value
	Total assets per capita	The ratio of total assets to current employees
	Return on equity	The ratio of net profit and net income to net assets
	Asset-liability ratio	Total assets to total liabilities ratio
Management capability	Department budget assessment	Budget implementation rate
	Growth rate of total revenue	The ratio of total revenue of that year to total revenue of the previous year
	Gross per capita income	Total income to current employees
	Growth rate of per capita compensation	The increase in employees' income in that year to last year's earnings
	Percentage of operating income	Operating income to total income

Table 3 Development capability evaluation system for business-class state-owned geological exploration units

Level indicators	The secondary indicators	Index to explain
Talent competition	Proportion of professional and technical personnel	Total number of professional and technical personnel at the end of the year to total number of employees
	Proportion of senior personnel	Middle and senior personnel to total number of employees
	Growth rate of technicians at the end of the year	Annual increase of technicians to total number of technicians at the end of last year
Innovation ability	Proportion of R&D personnel	Average number of personnel directly engaged in R&D to total number of employees
	Technical progress awards	Technical progress award level and quantity
	Proportion of technology R&D expenditure	Technical R&D expenditure to final sales income of the enterprise
Operation ability	Total assets per capita	Total assets to total number of employees
	Net profit margin on sales	Net profit to final sales income
	Return on equity	Total profits to net assets for the current year
	Profit growth rate	Growth in profits for the current year to total profits for the previous year
	Growth rate of total assets	Total assets growth for the current year to total assets for the previous year
	Net interest rate on assets	Net profit to average balance of assets
Enterprise culture	Industry awareness and social recognition	Whether the enterprise is well-known in the industry or in the society
	Corporate cohesion	Employee satisfaction degree of enterprise work
	Enterprise brand investment ratio	Annual brand promotion fee to final operating cost
	Corporate culture promotion	Whether to carry out a variety of forms of business philosophy propaganda and indoctrination

factors. Then each variable involved in the problem to be studied can be described by the sum of a small number of linear functions of common factors and special factors. Important factors are selected from them, each of which represents an economic function reflecting the interdependence of economic variables. Complex problems can be analyzed and explained with these important factors.

4.1 Weight

In the process of using factor analysis method to calculate weight index, it is to use the variance contribution rate of the cumulative contribution rate of each main factor proportion as a weight. We use SPSS to calculate index correlation coefficient matrix R, the correlation coefficient matrix characteristic value and variance contribution ratio. Then, the variance contribution ratio of the matrix of relevant variables is used as weight of each index.

4.2 Model

The core of factor analysis is factor analysis of several comprehensive indexes and extraction of common factors, and then the score function is the sum of the multiplier, which is equal to the variance contribution rate of each factor as the weight multiplied by the score of each factor. The mathematical expression of factor analysis method is matrix, namely:

$$X = AF + B \tag{1}$$

$$\begin{aligned} x_1 &= \alpha_{11} f_1 + \alpha_{12} f_2 + \alpha_{13} f_3 + \cdots \alpha_{1k} f_k + \beta_1 \\ x_2 &= \alpha_{21} f_1 + \alpha_{22} f_2 + \alpha_{23} f_3 + \cdots \alpha_{2k} f_k + \beta_2 \\ x_3 &= \alpha_{31} f_1 + \alpha_{32} f_2 + \alpha_{33} f_3 + \cdots \alpha_{3k} f_k + \beta_3 \\ &\cdots\cdots \\ x_{p(k \le p)} &= \alpha_{p1} f_1 + \alpha_{p2} f_2 + \alpha_{p3} f_3 + \cdots \alpha_{pk} f_k + \beta_p \end{aligned} \tag{2}$$

In the model, the vector $X\left(x_1, x_2, x_3, \cdots, x_p\right)$ is an observable random vector, namely the original observed variable.$F(f_1, f_2, f_3, \cdots, f_k)$ is the common factor of $X\left(x_1, x_2, x_3, \cdots, x_p\right)$, which is the factor appearing together in the expression of each original observation variable, and is the mutually independent unobservable theoretical variable. $A\left(\alpha_{\mathrm{ij}}\right)$ is the coefficient of common factor F, called factor loading matrix.

$\alpha_{ij}(\mathrm{i} = 1, 2 \ldots \cdots p;\ j = 1, 2 \ldots \cdots k)$ is called factor load, which is the load of the i original variable on the j factor, or can be regarded as the weight of the i variable on the j common factor. α_{ij} is the covariance and correlation coefficient of x_i and f_j. When the absolute value of α_{ij} is big, the load capacity of x_i from the common factor f_j is large. $B\left(\beta_1, \beta_2, \beta_3, \cdots, \beta_p\right)$ is a special factor of $X\left(x_1, x_2, x_3, \cdots, x_p\right)$, which cannot be included by the first k common factors, and this factor is also unobservable. The special factors are independent of each other and they are independent of all common factors [10].

4.3 Data

Dimensionless data:

This paper adopts the standardization method:

$$X_{ij}^{*} = \frac{X_{ij} - M_j}{S_i} \tag{3}$$

X_{ij}^{*} is the specific value of standardized secondary indicators.X_{ij} is the j secondary index value of unit i.M_j is the average value of the j secondary index. S_j is the standard deviation of the j secondary index.

4.4 Data Source

State-owned geological exploration units' development capability index data come from sixty localized geological exploration units of four provinces and cities of Beijing, Tianjin, Hebei, Shanxi. Quantitative data are provided by higher authorities. The data are reliable, objective, practical and reference value.

5 Results and Discussion

We obtained sixty units' development capability index data through questionnaire survey. Twenty units are the first category. Twenty units are the second category and Twenty units are the business category. Therefore, based on the evaluation index of development capability, this paper uses SPSS software to conduct factor analysis on these sixty state-owned geological exploration units, and obtains the development capability values of the first, second and business-class state-owned geological exploration units. In order to make the evaluation results comparable, six state-owned factors are selected as the main factors in this paper, in accordance with the principle that the cumulative variance contribution is greater than 70%. The cumulative variance contribution rate of the development capability factor analysis of first-class, second-class and business-class state-owned geological exploration units are 83.48, 85.12 and 71.45%, respectively, which fully meet the requirements, indicating that the model is highly reliable.

Due to the positive and negative development capability scores of localized exploration units obtained by factor analysis method, it is not consistent with common sense. At the same time, in order to facilitate the later empirical analysis, the results need to be turned into positive numbers. Therefore, the score is treated as a percentage. The specific method is to calculate the highest development capability score $D_{\max}$. The lowest score is $D_{\min}$. And the development capability average score is

$$D_{ave} = \left(\sum\nolimits_{i=1}^{n} D_i\right)/N \tag{4}$$

And then follow the formula

$$D_i^{'} = 60 + \frac{D_i - D_{ave}}{D_{max} - D_{min}} * 40 \tag{5}$$

The development capability score of units i is $D_i^{'}$, where $i = 1, 2, \cdots n$ [11] Table 4.

Table 4 Development capability assessment results

The type	Unit	Developmental ability value	Mean	Variance
First-class state-owned geological exploration units	A1	58.81	59.88	0.70
	A2	58.83		
	A3	58.94		
	A4	58.98		
	A5	59.17		
	A6	59.18		
	A7	59.35		
	A8	59.40		
	A9	59.59		
	A10	59.82		
	A11	59.84		
	A12	59.93		
	A13	59.98		
	A14	60.19		
	A15	60.36		
	A16	60.43		
	A17	60.54		
	A18	61.13		
	A19	61.51		
	A20	61.65		
Second-class state-owned geological exploration units	B1	46.62	59.87	50.40
	B2	50.27		
	B3	51.19		
	B4	54.29		
	B5	54.61		
	B6	55.36		
	B7	57.22		

(continued)

Table 4 (continued)

The type	Unit	Developmental ability value	Mean	Variance
	B8	58.37		
	B9	59.91		
	B10	60.01		
	B11	60.24		
	B12	60.27		
	B13	61.23		
	B14	61.37		
	B15	62.88		
	B16	63.03		
	B17	64.18		
	B18	67.92		
	B19	69.00		
	B20	79.53		
Business-class state-owned geological exploration units	C1	52.82	60.24	50.05
	C2	53.35		
	C3	54.81		
	C4	55.02		
	C5	56.42		
	C6	56.82		
	C7	56.95		
	C8	57.13		
	C9	57.85		
	C10	58.49		
	C11	58.64		
	C12	59.74		
	C13	59.80		
	C14	60.01		
	C15	62.03		
	C16	63.20		
	C17	63.43		
	C18	65.01		
	C19	66.74		
	C20	86.62		

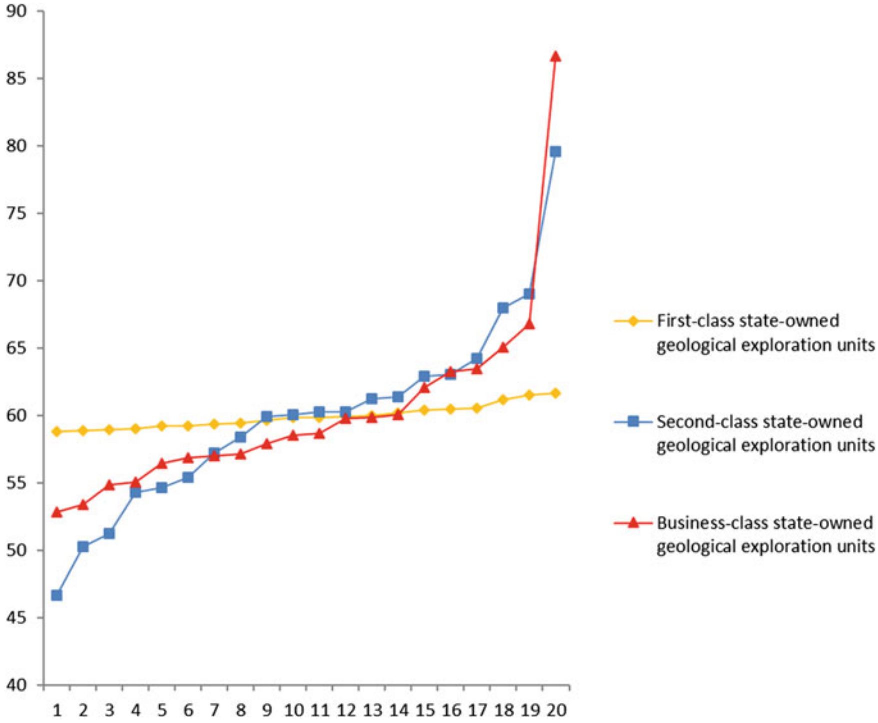

Fig. 1 Development capability evaluation value curve

The average development capability of first-class state-owned geological exploration units, which is 59.88, is higher than that in the second category, which is 59.87, and is lower than that in the business category, which is 60.24 lower than that in the business category. The variance of the development capability of first-class state-owned geological exploration units is 0.70, which is far lower than that in the second category, which is 50.40 and that in the business category, which is 50.05. It shows that the development level of first-class state-owned geological exploration units is relatively consistent, and the development level of each unit varies little. As we can see from the figure, the development capability of first-class state-owned geological exploration units fluctuates less around the level of 60. The mean and variance of second-class state-owned geological exploration units are 59.87 and 50.40 respectively, indicating that the development capability of second-class state-owned geological exploration units is the lowest. The lowest development capability of these sixty state-owned geological exploration units is also among the second category, with 46.62. The second category not only have a low overall development level, but also have uneven internal development level. The difference between the highest and lowest development capability is 70.59%. The mean and variance of business-class state-owned geological exploration units are 60.24 and 50.05, respectively, indicating that the overall development level of the business category is the highest. Meanwhile, the maximum development capability of these sixty state-owned geological exploration units is 86.62 of unit C20. However, the internal development of the business category is unbalanced. The difference between geological exploration units with the highest development capability and the lowest is as high as 63.99% Fig. 1.

6 Conclusion

Through building different development capability evaluation index system, collecting data, and using factor analysis method to calculate the development capability of three kinds of state-owned geological exploration unit, this paper is concluded that the development level of business-class state-owned geological exploration unit is highest, but there are great difference. The first-class state-owned geological exploration units' development level is higher and the level of development is consistent. The development level of second-class state-owned geological exploration units is lowest and the results show internal imbalance. The evaluation results show that the classification reform of Chinese geological exploration industry has obvious effects. The development level of business-class state-owned geological exploration units is higher than that of second-class state-owned geological exploration units, which have the nature of state-owned welfare and profit. The development level of first-class state-owned geological exploration unit is relatively balanced and not low. The evaluation results of the development capability of the classification reform of geological exploration units show that the development prospect of second-class state-owned geological exploration units is not as good as that of first-class state-owned geological exploration units and business-class state-owned geological exploration units.

As time goes on, the basic and advanced status of geological work has not changed, and the long-term favorable fundamentals of geological work have not changed, but the structure and requirements of geological exploration units are undergoing profound changes. Market economy calls for reform of state-owned geological exploration units. Geological exploration units should seize the opportunity of reform, combined with their own reality, classified as first-class and business-class state-owned geological exploration units. If the geological exploration units undertake more nonprofit geological work, we suggest that the reform of geological exploration units should be for first-class units. If more market projects are undertaken, we suggest that they should be reformed into business-class units. In the process of classification reform, we do not suggest that geological exploration units should be classified into second-class units.

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The Measurement Model of the Matching Degree Between Service Innovation Strategy and Innovation Capability of Manufacturing Enterprises and Its Application

Qi Wu and Weicai Wang

Abstract By analyzing the matching relationship between manufacturing enterprise service innovation strategy and innovation capability, this paper constructs the evaluation index system and measurement method of manufacturing enterprise's service innovation strategy intensity and innovation capability level. And using the concept of space geometry, the matching degree measurement model of manufacturing enterprise service innovation strategy and innovation ability is constructed. Using the case study method, the matching degree of the manufacturing enterprise service innovation strategy and innovation ability of the case study was measured.

Keywords Service innovation strategy · Innovation capability · Matching degree measurement model

1 Introduction

Since Vandermenwe and Rada first proposed the concept of manufacturing service, the research on the phenomenon of manufacturing service innovation has received widespread attention. Reference [1] first proposed the concept of manufacturing service. Reference [2] believed that the provision of value-added services from simple tangible products to product-based products was a clear trend in the simultaneous development of industrialization and service of Chinese manufacturing enterprises. Moreover, [2] believed that the implementation of the service-oriented manufacturing concept in China had accelerated the service innovation of manufacturing

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enterprises, which could promote the transformation of enterprises from pure manufacturing and processing to provide customers with all-round and life-cycle services, and the manufacturing business would be upgraded to the high-end value. Reference [3] believed that manufacturing companies relied solely on those traditional operational strategies that were stretched and needed to shift their focus from simple manufacturing to manufacturing and service integration. Early service innovation drawed on product innovation methods and emphasized the impact of industrial technology on service innovation. But the four characteristics of service intangibility, heterogeneity, simultaneity and perishability determined that service innovation and product innovation had certain differences. Reference [4] believed that manufacturing enterprise service innovation included three models for developing services related to enterprise products, developing services for specific relationships, and providing customers with overall problem solutions. The current Chinese manufacturing enterprises are facing the survival pressure of transformation and upgrading and value chain reshaping. Reference [5] proposed that the speed of technological innovation was accelerated, the life cycle of products was shortened, and the demand of consumers was continuously increasing. Only relying on technological innovation could no longer maintain the competitive advantage of enterprises. Reference [6] pointed out that China launched the "Made in China 2025" program, and "Made in China 2025" was a program of action for China's manufacturing industry and even China's economic transformation and upgrading. Meanwhile, [6] proposed that the "Made in China 2025" outline pointed out that it was necessary to accelerate the coordinated development of manufacturing and services, promoted the transformation of production-oriented manufacturing to service-oriented manufacturing, and developed service-oriented manufacturing as a task of manufacturing development. Reference [7] proposed that in the process of building service innovation and improving innovation capability, it was often accompanied by the interaction and dynamic matching between enterprise resource capability and organizational environment, and it had high contextual characteristics. Reference [8] proposed that the concept of matching originated from contingency theory and population ecology theory, and had been widely used to explain and analyze many phenomena in the field of strategic management. Exploring the service innovation capability of enterprises mainly had the following three perspectives: (1) As in [9], explore the difference between service innovation and technological innovation based on the perspective of new service development; as in [10], explore the types and dimensions of service innovation and the source of innovation; (2) As in [11], explore the role of enterprise learning capabilities, learning types in service innovation capabilities, and the impact on innovation performance based on organizational learning perspectives; (3) As in [12], explore how an enterprise's open network structure, network location, relationship commitment, and network capabilities affect its service innovation capabilities, emphasizing the synergy between the company and its stakeholders. As in [13], the synergy between companies and stakeholders was emphasized, especially the impact of customer engagement on business service innovation. In addition, [14] proposed that some scholars tried to explain the pre-factors, constituent dimensions, formation paths and innovation models of enterprise service innovation capabilities. However, the existing literature did not reveal the relationship between manufacturing enterprise service innovation strategy and innovation capability, and did not construct a measurement model for manufacturing enterprise service innovation and innovation capability matching degree. This paper intends to construct a measurement model for the matching degree of service innovation strategy and innovation capability of manufacturing enterprises in China context and apply it.

2 Modeling of the Matching Relationship Between Manufacturing Enterprise Service Innovation Strategy and Innovation Capability

A. *Establishing a Matching Model*

In the content of the manufacturing enterprise service innovation strategy, the service innovation resource status and service capability level, core technology choice, research and development investment intensity, and service application related resources all directly relate to the manufacturing enterprise's products. Therefore, they are merged into "product dimension". What is the content of service innovation, which part of the product value chain occurs in the product value chain, and which departments of the enterprise are involved in the organization and management of service innovation, and these contents are merged into the dimension of "process dimension"; What kind of services are needed by external enterprises, and which enterprises need service innovations, etc. This is a reflection of a cooperative relationship between the enterprise and other external enterprises; When product-based service innovation and product process-based service innovation are introduced into the market, they need to establish a close relationship with users, so they are merged into the dimension of "transfer dimension".

In terms of enterprise innovation capability, the academic community no longer only emphasizes that technological capability is the basic ability to achieve innovation success, and begins to realize and demonstrate the significant role of network capabilities and management capabilities in enterprise innovation, and incorporate them into the scope of enterprise innovation capabilities. Therefore, innovation capability can be considered to be composed of technical capabilities, management capabilities and network capabilities. The decision of the product dimension of the manufacturing enterprise needs to consider the technical capability of the enterprise, and the decision-making implementation of the product dimension will enhance the technical capability of the manufacturing enterprise; the decision-making of the process dimension needs to consider the enterprise management capability, and the implementation of the process dimension decision-making will enhance the management capability; The decision to transfer the dimension needs to consider the network capabilities of the enterprise, and the implementation of the delivery dimension decision will increase the network capacity of the manufacturing enterprise. There are certain

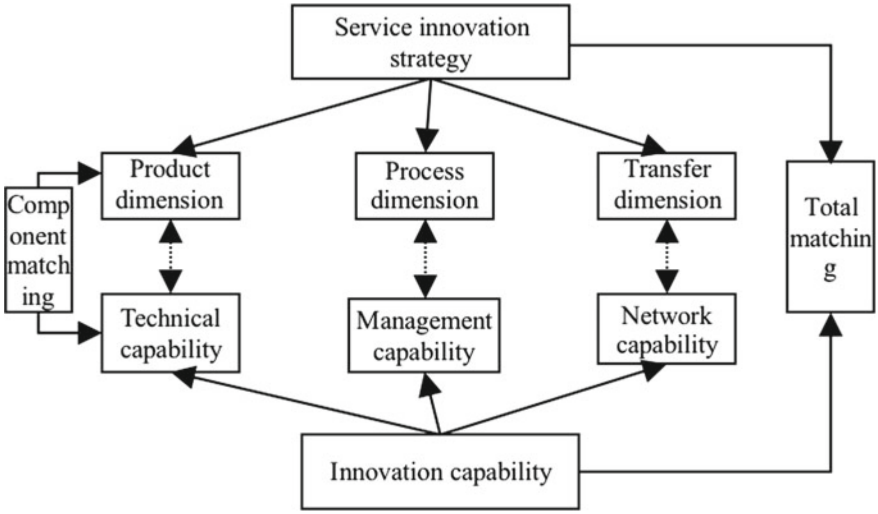

Fig. 1 Matching model of enterprise service innovation strategy and innovation capability

correspondences between the three dimensions of the service innovation strategy and the three components of the manufacturing innovation capability, as shown in Fig. 1.

B. *Matching Relationship Analysis*

The enterprise service innovation strategy and innovation ability evolved under the influence of their respective components. The balance between the strength of service innovation strategy and the level of innovation capability is the best point for manufacturing companies to achieve innovation success. The combination of different balance points constitutes the best development curve of the enterprise.

The balance between service innovation strategy (SI) and innovation capability (IC) is short-lived, and there are often gaps between them. In order to make up for the process of the two gaps, the process of acquiring innovation success is the process of enterprise success. The balance point between SI1 and IC1 is E1 (SI1, IC1), and the service innovation strategy and innovation capability match the most. If SI1 is unchanged, IC1 develops to IC2, the new balance point is E3, and E3 corresponds to SI3. The improvement of the level of innovation capability poses a challenge to SI1 and requires SI1 to be partially improved; If SI1 is unchanged, IC1 develops to IC2, the new balance point is E3, and E3 corresponds to SI3. The improvement of the level of innovation capability poses a challenge to SI1 and requires SI1 to be partially improved; If IC1 is unchanged, SI1 develops to SI2, the new equilibrium point is E4, and E4 corresponds to IC4 > IC1. The development of technology strategy challenges IC1 and requires IC1 to be partially improved. If the service innovation strategy and innovation capability are developed, from (SI1, IC1) to (SI2, IC2), a new equilibrium point E2 (SI2, IC2) will be reached, and the state of the enterprise in E2 is significantly higher than the E1 state.

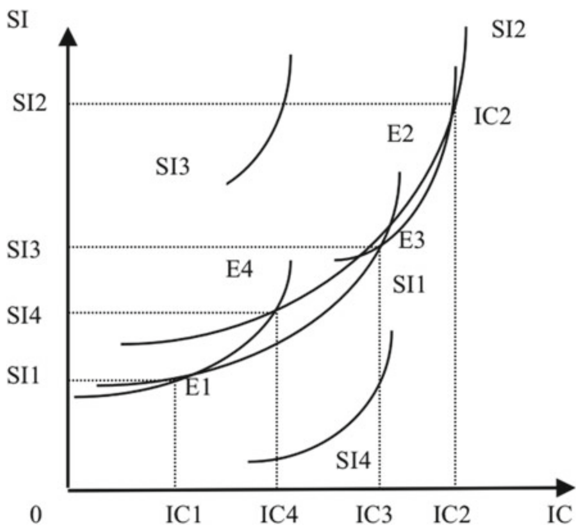

Fig. 2 Schematic diagram of the relationship between enterprise service innovation strategy and innovation capability

There may be a gap between the service innovation strategy and the innovation capability, but the "gap" cannot be too large, otherwise the manufacturing enterprise is seriously unbalanced and restricts the growth of the enterprise. If the enterprise's innovation capability is in the IC1 state and the service innovation strategy develops into SI3, the service innovation strategy far exceeds the limit of the company's current innovation capability. The service innovation strategy is unrealistic. The enterprise can only "to be moan his inadequacy in the face of a great task". If the service innovation strategy cannot be adjusted in time, the company will be at risk because of the enforcement of the strategy. If the service strategy at this time is SI4, the innovation capability of the enterprise far exceeds the requirements of the current strategy. The service innovation strategy at this time is not a good strategy, and the innovation capability cannot be improved because of the implementation strategy. E1 and E2 in Fig. 2 represent the best match between the service innovation strategy and the innovation capability, that is, the service innovation strategy and innovation capability achieve the greatest match. In fact, manufacturing companies are not always in the best match, allowing a gap between service innovation strategy and innovation capability. However, this "gap" cannot be too large, that is, the degree of matching between service innovation strategy and innovation capability needs to be certain. Within the scope, it is necessary to measure the matching between service innovation strategy and innovation capability.

3 Measurement of the Matching Degree Between Service Innovation Strategy and Innovation Capability of Manufacturing Enterprises

A. *Service Innovation Strategy System Evaluation Index System*

The service innovation capability evaluation index system is based on the research on the related issues of manufacturing enterprise service capability measurement. Reference [15] uses the number of customer needs processed per unit time as a measure of the service capabilities of the enterprise system; Reference [16] uses customer waiting time as a measure of product service capability; Reference [17] considers how much resources a supplier can use to determine its service capabilities; Reference [18] uses the number of types of services provided by a manufacturing company to its customers to reflect its degree of service. Reference [19] uses the two indicators of "resource input" and "quality of service" to measure the service differentiation of manufacturing enterprises; Reference [20] uses the quantity of service elements and the cost of service elements to measure the level of input and service of manufacturing enterprises; Reference [21] proposes the use of service rates as a measure of product service capabilities.

In summary, it can be seen that there are relatively few empirical studies on the service capabilities of manufacturing enterprises. Researchers often use a single indicator or a small number of indicators to measure the service capacity. Taking into account the special attributes of service activities, the combination of quantitative indicators and qualitative indicators is used for measurement. Based on the existing literature and the "Made in China 2025" plan, this study uses expert research methods to send letters to 10 experts in service management and operations management. After several rounds of discussion, the evaluation index system for service innovation of manufacturing enterprises was finally determined. The manufacturing enterprise service innovation strategy consists of three dimensions: product dimension, process dimension and delivery dimension. Based on the specific content of these three dimensions, an index system for measuring the strength of service innovation strategy of manufacturing enterprises is constructed (as shown in Table 1).

The measurement method of the service innovation strategy is as follows: (1) The weight is determined according to the constructed SI measurement index system. A questionnaire comparing the factor level indicators was designed, and 10 questionnaires were distributed to experts from the Ministry of Science and Technology. 10 questionnaires were collected and all were valid. The obtained data is collated and averaged, and a judgment matrix of the two comparisons is constructed; The AHP's judgment matrix method is used to calculate the weight vector v ij of each element under each criterion of SI, where i = 1, 2, 3, j = 1, 2, 3… … n. n is the number of features under the criterion of SI. The weight of each element is calculated by calculation (as shown in Table 1). (2) Calculate the strength of each SI subsystem. First, the experts score the elements in the subsystem of the SI (usually using the Likert scale) to obtain the score xij of the j-th element in the subsystem of SI, where

Table 1 Service innovation strategy measurement evaluation index

Criteria layer	Feature layer	Weight
Product dimension	Research and development of new products	0.15
	Research and development of core technologies	0.4
	Development of patent projects	0.25
	Product related resources	0.2
Process dimension	Management process optimization	0.2
	The use of technology in products and value chains	0.3
	Service Innovation in Organization Management	0.5
Transfer dimension	The timing and method of upstream customers and downstream customers	0.55
	When and how technology is introduced into the market	0.45

j = 1, 2, 3…… n. From this, the values of the SI subsystems can be calculated as:

$$Si = \sum_{j=1}^{n} v_{ij} x_{ij} \tag{1}$$

B. *Measurement of the Innovation Capability of Manufacturing Companies*

The previous analysis believes that the enterprise's innovation capability includes technical capability, management capability and network capability. Based on the connotation and structure of the three capabilities, an indicator system for measuring the level of innovation capability is constructed, as shown in Table 2.

The measurement methods of the level of innovation ability are as follows: (1) Determination of weight: According to the evaluation index system of IC level, a questionnaire comparing the factor level indicators is designed. Ten questionnaires were distributed to experts from Company A, and 10 questionnaires were collected, all of which were valid. The obtained data is collated and averaged, and a judgment matrix of the two comparisons is constructed. Then, using AHP's judgment matrix method, the weight vector w_{ij} of each element under each criterion of the IC relative to the criterion is calculated, where i = 1, 2, 3, j = 1, 2 …… m, m is the IC number of features under i criteria. The weight of each element is calculated by calculation (as shown in Table 2). (2) Calculate the strength of each subsystem of the IC. First, the experts will score the elements in the subsystem of the IC (using the Likert scale for scoring). Then, the score y_{ij} of the element in the subsystem of the IC is obtained, where j = 1, 2…… m. From this, the strength of each subsystem of the IC can be calculated as:

$$Ci = \sum_{j=1}^{m} w_{ij} y_{ij} \tag{2}$$

Table 2 Measured indicators of manufacturing companies innovative capabilities

Criteria layer	Feature layer	Weight
Technical capability	Proportion of R&D personnel	0.35
	The advanced level of new technology in the industry	0.15
	The advanced level of equipment in the industry	0.25
	The degree of automation of the entire process	0.25
Management capability	Employee management ability	0.2
	The ability to manage devices	0.3
	The ability to manage information	0.2
	The ability to manage the Financial	0.3
Network capability	The timing and method of upstream customers and downstream customers	0.25
	When and how technology is introduced into the market	0.2
	Network vision capability	0.25
	Network management capability	0.3

C. *Measurement Model of Total Matching Degree*

Since the service innovation strategy and innovation capability both contain three-dimensionality, this paper introduces the concept of distance between two points in 3-dimensional space. That is, the strengths (SI1, SI2, SI3) of the SI subsystems and the IC subsystems (IC1, IC2, IC3) interacting with SI are regarded as two points S and C in space. The distance between the service innovation strategy and the innovation ability is defined by the distance between two points. At the same time, establish a space sphere with the origin as the center and the distance from the origin to the innovation capability (the formula is: $r = \sqrt{\sum_{i=1}^{3} c_i^2}$) as the radius. Whether the SI intensity is insufficient or excessive is determined by whether the SI intensity (SI1, SI2, SI3) is located inside the sphere or outside the sphere.

Based on the above analysis, this paper gives a model for measuring the matching degree between enterprise service innovation strategy and innovation capability:

$$M_{sc} = \sqrt{\sum_{i=1}^{3} (s_i - c_i)^2} \tag{3}$$

In Fig. 3, d ∈ (0, r/6) is the threshold and d is usually determined by the expert. In this paper, SI and IC have three subsystems respectively, so take r/6 as the upper limit. The smaller the d value, the higher the matching requirement between SI and IC, so that the following criteria can be obtained: (1) When Msc ≤ d, it means that the enterprise's SI and IC are basically matched, and the smaller the Msc, the better the total matching degree. (2) When Msc > d, it means that the SI of the enterprise

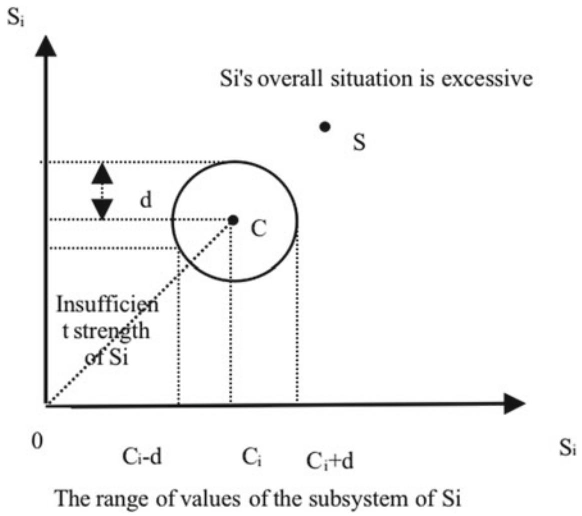

Fig. 3 Total matching and component matching schematic

is very mismatched with the IC as a whole. And if $\sum_{i=1}^{3} s_i^2 > r^2$, that is, the point S is outside the sphere, it indicates that the overall intensity of the SI is excessive; if $\sum_{i=1}^{3} s_i^2 < r^2$, that is, the point S is within the sphere, it indicates that the overall strength of the SI is insufficient.

D. *Measurement Model of Each Component Matching Degree*

In this paper, the degree of matching between SI subsystems and IC subsystems is evaluated by the degree of contrast of the projections of 2 points in each dimension in 3D space. According to the geometric knowledge, when the distance between the point SI (SI1, SI2, SI3) and the point IC (IC1, IC2, IC3) is not greater than d, the range of SI is [Ci-d, Ci+d]. Then, suppose Φi = |SI-CI|, i = 1, 2, 3. The criteria for judging the component matching degree are as follows: When ci-d ≤ SI ≤ ci+d, it indicates that the subsystem of SI basically matches the innovation capability subsystem. And the smaller the Xi is, the higher the matching degree is. When Xi = 0, it indicates that the subsystem of SI completely matches the innovation capability, which is the equilibrium point in Fig. 2.

4 Case Study

A. *Basic Development of the Company*

In order to verify the validity of the model, this paper selects B steel and iron company for case study. B steel and iron company is a large steel manufacturing enterprise in

China. The steel industry is a key industry that is related to national security and the lifeblood of the national economy. In the course of the company's development, B steel and iron company has gone through a successful road from technology introduction to independent innovation. Throughout the development process of B enterprise, the development of its development strategy can be roughly divided into two stages: the "high introduction, low R&D" stage of the first stage and the "high introduction, high R&D" stage of the second stage. At present, B steel and iron enterprise has very clear strategic plans for technological innovation and service innovation. The company focuses on independent research and development with technological innovation and customer-centric standards for service innovation. The company invested more than 100 million yuan in some major scientific research projects, and attached importance to the introduction and training of R&D personnel. It established a high-level R&D team consisting of 10 doctoral researchers, 122 master researchers and 68 senior technical researchers.

B steel and iron company attached great importance to service innovation. In the context of the Internet +, they extend to the upstream and downstream of the industry to provide personalized services and products to corporate customers. In addition, the company attaches great importance to the organization and management of innovation and the establishment and management of relationships with external networks, and its management capabilities and network capabilities have also been greatly enhanced.

B. *Calculate the Matching Degree of Service Innovation Strategy and Innovation Capability of B Steel Enterprises*

According to the service innovation strategy and innovation capability measurement index system, the questionnaire is designed. The questionnaire is based on the Likert five-point scale (1 is very poor, 5 is very good). Each indicator of service innovation and innovation capabilities of B steel and iron enterprise is investigated. The respondents include senior managers of B steel and iron enterprise, staff of the Ministry of Science and Technology, and managers of directors and above. A total of 110 questionnaires are distributed and 89 questionnaires are returned, of which 70 are valid questionnaires.

The reliability of the variables involved in the questionnaire is 0.813, which is greater than 0.70, indicating that the sample data has high reliability. It can be seen from the results of each variable validity test that the KMO values of each measurement scale are greater than 0.7, and the Bartlett significance probability is 0.000, which is less than 0.001, indicating that the data is correlated and suitable for factor analysis. The minimum value of the factor load is greater than 0.50, and the cumulative variance interpretation rate of the factor with the eigenvalue greater than 1 is greater than 50%, indicating that the structural validity test of each variable scale meets the statistical requirements. Using the scores of the various elements obtained from the survey, combined with the weights of the various elements, use Eq. (1) to calculate the strength of each SI subsystem: $SI1 = 3.20$, $SI2 = 2.20$, $SI3 = 2.45$. Calculate the strength of each IC subsystem using Eq. (2): $IC1 = 3.50$, $IC2 = 3.30$, IC3 = 2.15. Then $r = \sqrt{\sum_{i=1}^{3} c_i^2} = 5.269$, so that the threshold d = r/ 6 = 0.778 is selected.

Using formula (3) to calculate the total matching degree of service innovation strategy and innovation capability of B steel enterprise is $M_{sc} = 1.179, \sum_{i=1}^{3} S_i^2 = 21.084$. The matching degree of the strength of each subsystem of the service innovation strategy and the level of innovation capability are: [2.622, 4.378], [2. 422, 4.178], [1.272, 3.028].

C. *Analysis of the Matching Degree between B Steel Enterprises in Service Innovation Strategy and Innovation Capability*

(1) Total matching analysis. Since the total matching degree is: MSC = 1. 179 > d, it can be seen that the strength of the service innovation strategy of B steel and iron enterprise does not match the level of innovation capability, and because of $\sum_{i=1}^{3} S_i^2 = 21.084 < r^2$, it is considered that the strength of service innovation strategy of B steel and iron enterprise is insufficient. The overall matching of enterprise service innovation strategy and innovation capability is low, which directly limits the effective development of innovation activities and hinders the realization of innovation success. This can explain to a certain extent the reason why the development of service innovation strategy lags behind other enterprises in the same industry.

(2) Component matching analysis. Through the calculation of the component matching degree, it can be seen that the SI subsystem SI1 = 3.20 ∈ [2. 622, 4.378], SI3 = 2. 45 ∈ [1.272,3.028]. This shows that the strength of the B enterprise service innovation strategic product dimension and transmission dimension matches the level of innovation capability. And SI2 = 2.20 < 2.422, indicating that the strength of the service innovation strategy process of B steel and iron enterprise is insufficient. Through further analysis, it was found that the B steel and iron enterprise's service innovation process has a very low score for all three elements. Therefore, a further investigation was conducted on the B enterprise. Through investigations and interviews, it has been found that in recent years, enterprises have been paying attention to the supplement and improvement of service innovation resources, and attaching importance to the establishment of close relationships with external parties, while neglecting the effective management of service resources and service activities. This problem is also a common problem in many enterprises in China. These companies did not pay enough attention to how to effectively manage services, and did not treat service management activities as a core activity. Therefore, in the future, B enterprise should pay attention to information management and other content, and strengthen the organization and management of service innovation. It is necessary to pay attention to the timing and methods of upstream and downstream customers' expansion.

5 Implications

Through the analysis of the relationship between enterprise service innovation strategy and innovation capability, this paper finds that service innovation strategy and innovation capability are mutually promoted and mutually conditional. Only when they have a high degree of matching between the two can we ensure the successful realization of enterprise innovation and truly promote the growth of the enterprise. Based on the concept of space geometry, this paper constructs a measurement model for the matching degree between enterprise service innovation strategy and innovation capability. The model can measure the total matching degree and component matching degree of enterprise service innovation strategy and innovation capability. Through calculation, in addition to judging the matching state of enterprise service innovation strategy and innovation capability, we can also find the bottleneck in the service innovation strategy and innovation capability improvement. In this way, enterprises can make targeted improvements, ensure the smooth development of innovation activities, and accelerate the successful transformation of manufacturing enterprises to service-oriented manufacturing enterprises.

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Reverse Causality of Dividend Policy and Foreign Investment: Evidence from Pakistan

Hameeda Akhtar, Mashal Arif Chishtie, and Syed Zulfiqar Ali Shah

Abstract The research main objective is to examine the reverse causal relationship between dividend policy and foreign investment in Pakistan. This study provides a unique contribution in fulfilling the limitation of past studies in examining how and why dividend policy as a factor influences the foreign investment in Pakistan. The study used a generalized method of moment (GMM) estimation techniques on dynamic panel data models. This study collects the data from 84 nonfinancial firms listed on Pakistan stock exchange for 12 years from 2006–2017 with 1008 number of observations. The regression result reveals the positive impact of foreign investment on dividend policy. It shows that companies having high foreign investors are forced to increase dividend payout. In reverse, dividend policy also positively influences the foreign investment. Firms paying high dividends are capable to attract and increase foreign investments. Agency theory and signaling theory supports the findings of this study.

Keywords Dividend policy · Foreign investment · Signaling theory · Agency theory · Reverse causality

1 Introduction

Dividend policy is an unresolved financial problem. Regardless of broad contributed in the area of dividend policy it is still an unclear issue [1]. After observing past studies, the influence of foreign investment on dividend policy is debated a lot in the developed and developing economies while to examine dividend policy as a

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determinant is still limited [2]. Therefore, the research objective is to examine the reverse causal relationship between dividend policy and foreign investment in the Pakistani equity market.

The study significance is as follow. Dividend policy widely contributes to the benefit of stock market considering that firms' dividend policy plays a vital role in foreign investments. The greater demand for foreign investment needs higher stability in dividend payout. The implementation of the results of this study by non-financial firms will be enabling them to increase foreign investments. The study guides the foreign investors to protect their wealth through controlling mechanism by holding greater ownership concentration. It also leads managers to create the firms' positive image by stable dividend payout for attracting foreign investors. Scholars mostly have studied the determinants of dividend policy in Pakistan but they have neglected to analyze in what way dividend policy influences foreign investment. The study helps future researchers to uncover the neglected areas in dividend policy by examining it as a determinant.

The paper provides a novel contribution to existing literature. Authors have extensively researched to reconcile problems in the area of dividend policy. Irrespective of that it has created problems in the field of finance. Dividend policy as a determinant is studied in Chinese and Indian equity markets but is neglected in the Pakistani equity market. Therefore, it is predominant to analyze the direct and reverse relationship between foreign investment and dividend policy in Pakistani capital market [2, 3]. Dividend policy is widely studied in the financial sector. As financial based institutions payout frequent dividends as compare to nonfinancial firms therefore, the study target industrial firms to understand the role of dividend policy [4].

2 Literature

2.1 *Foreign Investment and Dividend Policy in Developed Economies*

Authors in Taiwan equity market reveal the positive and significant impact of foreign investment on dividend policy. After collecting data from the Taiwan stock market, it is evident that foreign investors play a vital role in stimulating firms to pay high dividends. Pecking order theory supports this finding [5].

After collecting data from the Warsaw stock exchange from the period of 2004–2014, the study finds a positive impact of foreign investment on dividend policy. Initially, on the basis of the binary logit model, the increase in foreign shareholding in lag periods Y_{t-1} tends to significantly increase the dividend payout at time t. According to the multinomial logit model, the increase in foreign shareholding in lag periods Y_{t-1} tends to significantly decrease the dividend payout at time t. These results were highly supporting the pecking order theory despite signaling theory and cash flow theory [6]. In contrast to this, analyzing the Swedish stock market, foreign investors demand firms to pay lower dividends due to their preference for capital gain [7].

2.2 Foreign Investment and Dividend Policy in Developing Economies

After testing the direct and reverse relationship between dividend policy and foreign ownership in Indian stock market, it is evident that cash dividend-paying firms have the propensity to increase foreign investments. The clientele theory supports this finding [3].

In compare to this, authors also state the negative relationship between foreign investment and dividend policy in the Turkish stock market. Foreign investors lower their demand for dividend payout due to the high tax burden and they prefer capital gain for availing tax benefits [8]. Similarly, there exists a negative relationship between foreign shareholding and dividend payout in Vietnam stock market. Foreign investors increase their investment in those firms who payout low dividends. They demand from managers to reserve a large amount of income within the firm for availing opportunities to give future growth to the company [9].

2.3 Foreign Investment and Dividend Policy in Pakistani Emerging Market

Large ownership of shares by institutions and foreign investors reduces and control the opportunistic behavior of managers in expropriating the wealth of shareholders by increasing the dividends. Institutional ownership brings 23% of the change in dividend policy while foreign ownership brings 25% of the significant change in dividend policy as compared to managerial ownership which brings 18% change in dividend policy [10].

Authors after collecting data from Pakistan stock market find the significant positive influence of foreign investment on dividend policy. Foreign investor demand cash dividend due to the threat of terrorism and inconsistencies in the political circumstances of Pakistan that expropriate their wealth. So, foreign investors through cash dividend payment provide safety to their wealth [11].

This research is ordered as follow. Section 1 shows the introduction. Section 2 shows the literature review. Section 3 shows the research methodology. Section 4 represents the empirical findings. Section 5 represents the study conclusion.

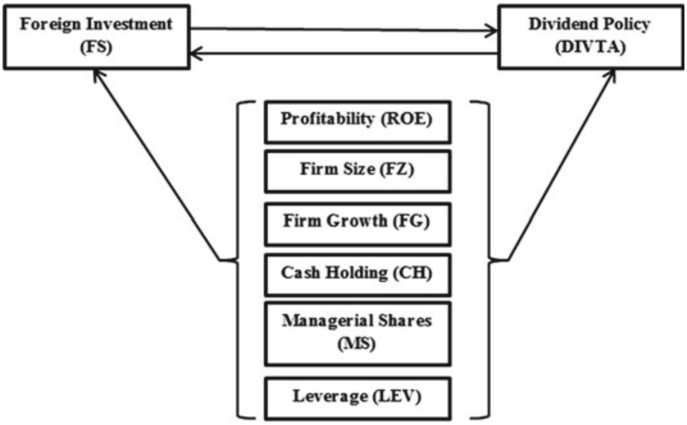

Fig. 1 The relationship between dividend policy and foreign investment

2.4 Research Model of Study

The research model of the study represents the conceptual framework as shown below:

Figure 1 depicts the relationship between dividend policy and foreign investment. The direct arrow shows the influence of foreign investment on dividend policy. In the direct model dividend policy is taken as the dependent variable and foreign investment is taken as an independent variable.

The reverse arrow shows the influence of dividend policy on foreign investment. In the reverse model, foreign investment is taken as the dependent variable and dividend policy is taken as an independent variable. In middle are the control variables including firm size, firm growth, cash holding, managerial shares, return on equity (profitability) and firm leverage.

3 Research Methodology

3.1 Data Collection and Sampling Technique

This research was carried out in a methodical manner to fulfill the research characteristics. It included the testing of data set and supporting results.

The study incorporated the quantitative research design for empirically testing the hypothesis. It excluded all financial firms including banks, insurance companies as they function under high debts. Hence, the final sample contained 84 nonfinancial firms that pay dividends even in one year of the sample period from 2006 to 2017.

The study sample contained only dividend-paying firms and excluded non-dividend paying firms in order to observe its relationship with foreign investment.

In order to select an appropriate representative sample, the judgmental sampling technique a type of non-probability sampling technique was employed. It helped to collect information from a specific group of firms which do not only contain data on dividend policy but also on foreign investment.

The study used authenticate source for data collection to increase the research credibility. Foreign investment data were collected from annual reports available on the companies' official website and open doors.pk website. Dividend policy data were collected from financial statement analysis of nonfinancial firms published by the State bank of Pakistan. Similarly, data on return on equity, managerial shares, leverage, and firm growth, cash holding and firm size were obtained from financial statement analysis published by state bank of Pakistan.

This study used precise measurements of variables. It measured dividend policy through the ratio of dividend to total asset indicated as DIVTA [12]. The percentage of the number of shares held by foreign investors was used as a proxy for measuring the foreign investment which was indicated as FS [13]. Natural logarithm of total asset of the firm was used as a proxy of the firm size represented as FZ [14]. Profitability ROE was measured through return on equity after tax. Leverage denoted as LEV was measured as a total debt of firms divided by total assets of the firm [15]. Cash holding denoted as CH was measured as the ratio of cash (cash and bank balance) divided by total assets of the firm [16]. Firm growth denoted as FG was measured as a change in total assets. Managerial shares denoted as MS was measured as the number of shares owned by managers, directors, and their family members [17].

The study contained strongly balance panel data. Before conducting the regression analysis, the data were identified with various econometric problems which required suitable treatments. It included the issue of heteroscedasticity which was identified through the Breusch Pagan test. Wald test was used to diagnose the endogeneity issue. Similarly, Wooldridge test and omitted variable biases test were used to determine autocorrelation (serial correlation) and omitted variable biases.

To tackle the above issues and to improve the research accuracy, generalized method of moment (GMM) estimation techniques were appropriate to give minimum errors which automatically control the problems of endogeneity, heteroscedasticity, autocorrelation and omitted variable biases.

This technique included difference generalized method of moment and system generalized method of the moment. Hausman specification test was used in model 2 to identify suitable model among fixed effect and random. If the random effect model was an appropriate model then it specifies the persistence of variables over time, the study would prefer system generalized method of the moment to obtain precise results.

This research conducted the same procedures and used valid instruments to get similar results for increasing its reliability and accuracy. Sargan test was also conducted to identify the instrument validity.

3.2 Regression Equations

There is a matter of "history" in a dynamic panel data model. Firms maintain smooth dividend by increasing dividend payout. Hence current year dividend policy is influenced by its past year dividend policy.

Similarly, current investments made by foreign stockholders are also influenced by its past year foreign investment. In both regression equations, the current year dependent variable is influenced by its past year taken as an independent variable.

Hence, below are the regression equations of model 1 and model 2 for showing the direct and reverse relationship between dividend policy and foreign investment.

$$\begin{aligned} DIVTA_{it} &= \beta_0 + \beta_1(DIVTA)_{it\text{-}1} + \beta_2(FS)_{it} + \beta_3(ROE)_{it} \\ &+ \beta_4(FZ)_{it} + \beta_5(FG)_{it} + \beta_6(CH)_{it} \\ &+ \beta 7(\mathrm{MS})\mathrm{it} + \beta_8(LEV)_{it} + \epsilon_{\mathrm{it}} \end{aligned} \tag{1}$$

$$\begin{aligned} FS_{it} &= \beta_0 + \beta_1(FS)_{it-1} + \beta_2(DIVTA)_{it} + \beta_3(ROE)_{it} \\ &+ \beta_4(FZ)_{it} + \beta 5\,(FG)_{it} + \beta_6(CH)_{it} \\ &+ \beta 7\,(\mathrm{MS})\;\mathrm{it} + \beta_8(LEV)_{it} + \epsilon_{\mathrm{it}} \end{aligned} \tag{2}$$

Symbols of equations are shown as: FS = percentage of shares held by foreign investors known as foreign investment; DIVTA = dividend to total asset known as dividend policy; FZ = size of firm; ROE = return on equity (profitability of firm); LEV = firm leverage; MS = managerial shares; CH = firm cash holding; DIVTA $_{\text{it-1}}$ = lag of dividend policy, FS $_{\text{it-1}}$ = lag of foreign investment, i = number of firms; t is time = 1, 2, 3, …12; β_0 = intercept (constant); β_1, β_2, $\beta_3 \ldots\ldots \beta_8$ are coefficients of explanatory variables which shows how much change is coming in dependent variable due to independent variables; ϵ_{it} = error term which may be due to ignorance of variables by the study that may influence the dependent variables within models.

The presence of a lag dependent variable in regression equations require efficient estimator that is a generalized method of moment (GMM) estimation techniques. It takes lag and difference values as an instrument of lagged dependent variable under the condition of endogeneity which shows the relation between a lag dependent variable and the error term. However, difference generalized method of moment technique may be biased in the finite sample due to which this study also prefers and reports the results of the system generalized method of the moment.

4 Results and Discussions

This section is divided into two parts. One part of the result shows diagnostic tests and the second part shows the regression analysis.

4.1 Diagnostic Tests

The diagnostic tests are carried out before running the regression analysis in order to get precise results.

The diagnostic testing on the panel data includes descriptive statistics to determine the outliers within the data set before regression analysis.

Table 1 represents descriptive statistics for the sample of 1008 observations. Mean, standard deviation, maximum and minimum values are reported for all variables. Descriptive statistics of all variables including dependent, independent and control variables have shown an acceptable gap between minimum and maximum values. It shows that there are minimum outliers within the data set therefore; we can get more accurate results in regression analysis.

This study used Multicollinearity test for identifying multicollinearity problem among explanatory variables. The values of variation inflation factor (VIF) of each variable in Tables 2 and 3 are below the standard level 7 which has confirmed that there is no problem of multicollinearity among explanatory variables. Multicollinearity problem may exist if the variation inflation factor of variables exceeds above the standard level of 7.

Table 1 Descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Dividend policy	1008	0.529	0.111	0.000	1.964
Foreign investment	1008	0.068	0.162	0.000	0.891
Profitability	1008	0.197	0.244	−0.968	1.367
Firm size	1008	16.218	1.954	12.267	24.111
Firm growth	1008	0.140	0.252	−0.999	3.851
Cash holding	1008	0.073	0.099	0.000	0.706
Managerial shares	1008	0.158	0.229	0.000	0.987
Leverage	1008	0.489	0.212	0.031	0.985

Table 2 Multicollinearity test of model 1

Variables	VIF	1/VIF
Foreign investment	1.05	0.956
Profitability	1.09	0.919
Firm size	1.05	0.950
Firm growth	1.03	0.967
Cash holding	1.08	0.927
Managerial shares	1.08	0.923
Leverage	1.06	0.941
Mean VIF	1.06	

Table 3 Multicollinearity test of model 2

Variables	VIF	1/VIF
Dividend policy	1.12	0.894
Profitability	1.13	0.882
Firm size	1.05	0.951
Firm growth	1.04	0.961
Cash holding	1.10	0.913
Managerial shares	1.07	0.934
Leverage	1.05	0.949
Mean VIF	1.08	

Additionally, this study used Breusch Pagan analysis for testing heteroscedasticity. H_0 reports homoscedasticity but the significant probability *p*-values that is Prob > Chi2 = 0.000 in model 1 and model 2 respectively reject the null hypothesis and accepts the alternative hypothesis H_1 which shows the presence of heteroscedasticity. Wald test of endogeneity is applied to identifying the presence of endogenous variables. Null hypothesis H_0 shows that independent variables are exogenous but the significance of probability *p*-values that is Prob > chi2 = 0.000 in both models confirms the acceptance of alternative hypothesis H_1. Foreign investment in model 1 and dividend policy in model 2 are endogenous variables. There is an association of independent variables with error terms in both the models. Endogeneity problem is present due to reverse causality of dividend policy and foreign investment.

The paper also conducted the test of omitted variable biases for both of the models. Null hypothesis H_0 shows no existence of omitted variables while alternative hypothesis H_1 shows the presence of omitted variables. The significance of probability *p*-values that is Prob > chi2 = 0.005 and Prob > chi2 = 0.000 confirms the acceptance of alternative hypothesis H_1 for both models. Similarly, Wooldridge test is also conducted for analyzing the autocorrelation in panel data. Null hypothesis H_0 shows no first-order autocorrelation while H_1 shows the first-order autocorrelation. The significance of probability *p*-values that is Prob > F = 0.000 and Prob > F = 0.0001 confirms the acceptance of alternative hypothesis H_1 which represents the existence of autocorrelation (serial correlation) in both models.

After diagnosing the data, this study used a generalized method of moment (GMM) estimation techniques as an efficient estimator to solve the above-mentioned issues.

4.2 Dynamic Panel Data Model

The study represents the dynamic nature of model 1 and model 2.

According to past theoretical justification current dividend policy is not only influenced by the current factors but it is also influenced by firms' previous year dividend policy. Similarly, the current value of foreign investment is not only influenced by current aspects but it is also influenced by its past values.

4.3 Foreign Investment and Dividend Policy in a Direct Model

In Tables 4 and 5, the results indicate the positive and strong significant impact of foreign investment on dividend policy. Foreign investors with high ownership concentration indirectly control the self- interest behavior of managers. With high ownership concentration, they reduce agency conflict by incorporating the controlling mechanisms on directors to provide safety measures to their wealth. The finding is consistent with agency theory. The result is also in line with the findings of [18].

Table 4 The result of dynamic panel data model 1 using Arellano Bond estimation

Dividend payout DIVTA		
Independent variables	Coefficient	p-values
Lag dividend policy ($DIVTA_{t-1}$)	0.080	0.000***
Foreign investment (FS)	0.010	0.000***
Profitability (ROE)	0.007	0.000***
Firm size (FZ)	0.007	0.000***
Firm growth (FG)	−0.016	0.000***
Cash holding (CH)	0.077	0.000***
Managerial shares (MS)	−0.013	0.019**
Leverage (LEV)	−0.037	0.000***
Sargan (*p*-value)		0.4141

Table 5 The result of dynamic panel data model 1 using Arellano Bover estimation

Dividend payout DIVTA		
Independent variables	Coefficient	p-values
Lag dividend policy ($DIVTAt_{-1}$)	0.278	0.000 ***
Foreign investment (FS)	0.022	0.000***
Profitability (ROE)	0.017	0.000***
Firm size (FZ)	0.001	0.001***
Firm growth (FG)	−0.011	0.000***
Cash holding (CH)	0.203	0.000***
Managerial shares (MS)	−0.029	0.000***
Leverage (LEV)	−0.073	0.000***
Sargan (*p*-value)		0.2685

In Tables 4 and 5, Lag dividend policy has a positive and strong significant influence on the current dividend policy. Return on equity has a positive and strong significant impact on dividend policy. It shows high profitable firms have a tendency to maintain the stable dividend payout. Firm size positively influences dividend policy due to its high-profit margin. High growth firms negatively influence dividend policy. The firm needs internal financing to invest in various schemes for expanding their business. So they decrease the dividend payouts. Leverage negatively influence dividend policy as it causes bankruptcy risk and transaction costs which reduces dividend payout. Cash holding has a positive impact on dividend policy. It shows that firms with excess cash holding are able to increase the distribution of dividends. The negative and significant relationship between managerial share and dividend policy shows high ownership concentration of managers allow them to aggregate internal deposits for financing the firm investment decisions. As a result, firms reduce the dividend payout by expropriating the shareholders' wealth [6].

4.4 Dividend Policy and Foreign Investment in the Reverse Model

Table 6 and 7 shows the positive and significant impact of dividend policy on foreign investment. This illustrates that managers are aware of firms' private information. A stable dividend signals the firm good corporate governance and better financial prospects which attracts the foreign investors. The finding of this study is consistent with signaling theory. The result is similar to [2].

In Tables 6 and 7, Lag foreign investment has a positive and strong significant influence on the current foreign investment. Managerial shares negatively influence foreign investment as they use the dividend policy as a substitute mechanism in

Table 6 The result of dynamic panel data model 2 using Arellano Bond estimation

Foreign investment FS		
Independent variables	Coefficient	p-values
Lag foreign investment (FS_{t-1})	0.628	0.000***
Dividend policy (DIVTA)	0.010	0.000***
Profitability (ROE)	0.019	0.000***
Firm size (FZ)	−0.006	0.000***
Firm growth (FG)	0.009	0.000***
Cash holding (CH)	0.004	0.000***
Managerial shares (MS)	−0.203	0.000***
Leverage (LEV)	0.002	0.000***
Sargan (*p*-value)		0.4193

Table 7 The result of dynamic panel data model 2 using Arellano Bover estimation

Foreign investment FS		
Independent variables	Coefficient	p-values
Lag foreign investment (FS_{t-1})	0.749	0.000***
Dividend policy (DIVTA)	0.002	0.001***
Profitability (ROE)	0.031	0.000***
Firm size (FZ)	0.002	0.000***
Firm growth (FG)	0.005	0.000***
Cash holding (CH)	−0.009	0.000***
Managerial shares (MS)	−0.202	0.000***
Leverage (LEV)	0.005	0.000***
Sargan (*p*-value)		0.7123

expropriating minority shareholders wealth which reduces foreign investment. Profitability has a positive and strong significant impact on foreign investment. High profitable firms have high ability to protect foreign shareholders' wealth thus increases foreign investment. Firm leverage has a positive and strong significant impact on foreign investment. Cash holding has a negative and strong significant impact on foreign investment. Large size firms have a positive and strong significant impact on foreign investment. Listing of large size firms on international exchange, high market liquidity and increase in exports sales enable firms to attract and increase the foreign investment.

The study prefers the result of system generalized method of the moment in model 2 due to the persistence of variables over time which is determined through the Hausman specification test. It shows that the random effect model is appropriate with significance probability *p*-value that is Prob > chi2 = 0.951. Hence, it becomes invalid to prefer difference generalized method of the moment due to non-robustness and imprecise results [19].

Sargan test is used for identifying the validity of instruments. The study validates the instruments through the Sargan test by showing insignificant value in model 1 (P > chi2 = 0.327). The insignificant value in Model 2 (P > chi2 = 0.521) also provides instrument validity. These valid instruments give accurate results.

The results were also reliable after repeatedly analyzing the data. *, **, *** are for the level of 10, 5, 1% respectively.

5 Conclusion and Suggestion of the Study

After empirically testing financial data of dividend policy and foreign investment from the period of 2006 to 2017, the study finds the significant and positive influence of foreign investment on dividend policy. This demonstrates that foreign investors effectively control organizational practices. They make certain decisions for lowering agency conflicts between foreign stockholders and firm managers. In this way, foreign investors increase the distribution of dividends. In reverse, the result of the dynamic panel data model 2 shows that dividend policy significantly describes the positive variation in foreign investment. This specifies that Pakistani stock listed firms attract foreign investors by increasing and maintaining smooth dividend payouts. This signals the good financial performance and firms' growth in the coming future. Hence, managers increase foreign investor value by increasing dividend payout. The results of this study are reliable with the agency theory and signaling theory. The results were consistent in using the same procedures repetitively. Similar results each time increase the research reliability [20].

The study provides suggestions on the basis of research limitations. The study collated limited data from the period of 2006 till 2017 on 84 non-financial firms. Therefore, the sample size and time period could be expanded for generalizability of the study and for observing the long run relationship between the main variables. Dividend policy and foreign investment relationship could be observed by comparing different emerging economies such as BRIC countries (Brazil, Russia, India, and China). The influence of dividend policy on foreign investment and local investment could be examined by comparing the financial and non-financial organizations. Future research could examine the influence of managerial ownership and firm performance on foreign investment under the moderating role of CEO duality in Pakistan. In order to make results more robust future study could use 2SLS estimation techniques in the presence of the issue of endogeneity. In order to make results more interesting, it could also use the different measurement of variables used in this study.

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Pricing Catastrophe Bond of Agricultural Products Price Fluctuation Based on POT Model

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Abstract In recent years, extreme risk of agricultural products price fluctuation has become the hotspot of social concern, the key point of management decision-making and the difficulty of theoretical studies. As an innovative financial instrument, catastrophe bonds provide a new path for catastrophe risk management. Therefore, this paper aims to provide the methodology of pricing catastrophe bond of agricultural products price fluctuation, which can be shown as the steps of constructing time series of agricultural products price fluctuation, fitting extreme risk distribution using POT model from extreme value theory, and calculating a one-year zero-interest catastrophe bond under different parameter assumptions. This paper selects Fuji apple as an example to make empirical analysis. This study is a profitable attempt to construct the mechanism of catastrophic risk decentralization agricultural products price fluctuation.

Keywords Agricultural products price fluctuation · Extreme risk · POT model · Catastrophe bond · Fuji apple

1 Introduction

The frequent and sharp price fluctuation of some agricultural product such as pork, eggs, fruits and vegetables have a huge effect on agricultural production and household consumption in China. It is necessary to establish a supporting catastrophe risk management system to cope with the occurrence of extreme risk losses. Facing with

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the catastrophe risk, it is difficult to react effectively by relying on the traditional insurance management method. In recent years, some foreign insurance companies have launched various innovative financial tools such as catastrophe bonds, linking the insurance market to the capital market and seeking investors to disperse the risk of (re)insurance companies in the capital market. The researches on the theoretical pricing model of catastrophe bonds in overseas are earlier. Morton proposed a LFC model in which the price of catastrophe bonds consists of a catastrophe expected losses plus an expected excess return [1]. Wang derived catastrophe bond pricing based on the catastrophe risk survival function after the Wang transformation model [2]. Based on the risk conversion model proposed by Wang, Christofides derived a more concise and efficient catastrophe bond theoretical price through two approximations [3]. Wang proposed a more accurate Wang two-factor model based on his own transformation model [4]. Our researchers have used the above models to measure the bond prices. For example, Tian and Xiang used the Christofides model to obtain a rough catastrophe bond price range. Zhu, Zhou and Yan, Wei and Weng et al. [5–8], Deng and Yan and Lei estimated the price of catastrophe bonds based on the Wang two-factor model [9, 10].

In the empirical study of domestic catastrophe risk bonds, more research on catastrophe bonds for natural disasters. Such as Shi and Qi, Hu, Yang, Shi and Qin, Ma and Ma, Wang, Shang et al., respectively apply the extreme value theory applies to the pricing calculation of catastrophe bonds, and uses the generalized Pareto distribution and bond pricing model to price the catastrophe bonds of natural disasters [11–16]. And for researches on Bonding of Agricultural Catastrophe Risk, Huang and Zhao, Li and Tan, Huang, Guo et al., based on the researches on tobacco production in Yunnan, cotton production in Anhui Province and rubber production in Hainan, designed catastrophe bond to diffuse the risk of agricultural planting [17–19]. Liu and Fang, Chang, Han and Li et al. via the analysis of market demand and feasibility of agricultural catastrophe bonds respectively, believe that the development of agricultural catastrophe bonds in China has great potential [20–22]. Zhan and Lin et al. based on the POT model in extreme value theory, a one-year zero-interest agricultural catastrophe risk bond was designed via the study of the risk of crop catastrophe losses in Guangdong Province [23]. However, there are few clear and systematic literatures research on the catastrophe bond about the “catastrophe” risk of agricultural products price fluctuation.

Under this background, this paper attempts to construct the catastrophe bond model of agricultural products price fluctuation. At the same time, taking Fuji apple as an example to make empirical analysis and put forward some corresponding policy suggestions.

2 Theoretical Analysis Framework

2.1 Constructing Time Series of Agricultural Products Price Fluctuation

For the price of agricultural products, it is necessary to eliminate the influence of monetary factors and correct them with the Consumer Price Index (CPI) to obtain the actual price of agricultural products. In theory, the price of agricultural products may increase in the long term due to the input of production factors. According to the selection criteria of target production in agricultural product cultivation insurance, this paper takes the long-term trend price of agricultural product price as the target price, and obtains the fluctuation time sequence of agricultural product price by calculating the deviation degree between actual price and trend price. In this paper, we use the H-P filtering method to determine the long-term trend price, and obtain the agricultural product price fluctuation time series (also called the fluctuation index X). The equation is as follows:

$$X_i = \frac{\widehat{P} - P_i}{\widehat{P}}, i = 1, \ldots, n \tag{1}$$

where $\widehat{P}$ is the trend price and P_i is the actual observed value.

2.1.1 Fitting Extreme Risk Distribution of Agricultural Products Price Fluctuation

As one of the unique research fields in modern statistics, extreme value theory is the theory of studying the distribution characteristics of sequence extreme values. In practical applications, since only the tail section is considered, it is possible to reasonably model the tail section and provide a more scientific study of extreme risk measurement [24]. In this paper, we use the Peaks Over Threshold (POT) and Generalized Pareto Distribution (GPD) to fit the tail distribution of the agricultural product price fluctuation sequence X_i, and get the tail distribution function $F(x)$. The POT model takes all the observed values that have reached or exceeded a certain fixed threshold as sample data and obtains the GPD distribution by fitting the tail distribution of the sample sequence. Let ξ be the shape parameter, σ be the scale parameter, and u be the position parameter, then define the GPD distribution function as:

$$G(x; u, \xi, \sigma) = \begin{cases} 1 - \left(1 + \xi \frac{x-u}{\sigma}\right)^{-1/\xi}, \ \xi \neq 0 \\ 1 - \exp\left(-\frac{x-u}{\sigma}\right), \ \xi = 0 \end{cases} \tag{2}$$

When $\xi \geq 0, x - u \geq 0$ and $\xi < 0, 0 \leq x - u \leq -\frac{\sigma}{\xi}; \sigma > 0.$

The GPD distribution fitted all the observed data that exceeded the threshold, and the excess distribution function is used. Assuming that $X_1, X_2, \cdots, X_n$ are independent identically distributed random variables, then the distribution beyond the threshold ($Y_i = X_i - u$) is called the excess distribution function and it is

$$F_u(y) = P(X - u \leq y | X > u) = \frac{F(y+u) - F(u)}{1 - F(u)} = \frac{F(x) - F(u)}{1 - F(u)} \tag{3}$$

The population distribution function $F(x)$ was obtained indirectly by using the conditional excess distribution function, i.e.

$$F(x) = [1 - F(u)]F_u(y) + F(u) \tag{4}$$

According to the PBdH theorem [25, 26], when the threshold u is sufficiently large, $F_u(y)$ can be obtained by a good approximating with the GPD distribution $G(x; u, \xi, \sigma)$; $F(u)$ is estimated from $1 - \frac{N_u}{n}$ according to historical simulation, where n is the total sample size and N_u is the sample size exceeding the threshold. Therefore, the tail estimate can be expressed as:

$$F(x) = \begin{cases} 1 - \frac{N_u}{n}\left(1 + \xi\frac{x-u}{\sigma}\right)^{-\frac{1}{\xi}}, \xi \neq 0 \\ 1 - \frac{N_u}{n}\exp\left(-\frac{x-u}{\sigma}\right), \xi = 0 \end{cases} \tag{5}$$

2.1.2 Pricing Catastrophe Bond Model

The key to the successful issuance of agricultural catastrophe bonds lies in the reasonable estimation and determination of prices, and the basis of reasonable pricing stems from the arrangement and setting of trigger mechanisms. The trigger mechanism is a clear definition of the trigger event, usually in the form of an agreed contract, which is the basis for judging whether the two parties need to pay and the amount to pay when the losses occurs. According to the characteristics of different catastrophe losses, it is divided into actual loss trigger mechanism, index trigger mechanism and medley trigger mechanism.

In accordance to the tail distribution model based on the agricultural price fluctuation sequence, the trigger condition should be that the deviation between the actual price and the trend price reaches a certain trigger value, therefore the index trigger mechanism was selected, which is much simple, convenient and to avoid moral hazard. The main steps in the catastrophe bond pricing process are: First, estimate the tail distribution of the agricultural product price fluctuation sequence under the catastrophe contract, i.e., the GPD distribution function $F(x)$, and obtain the probability at the trigger level. Second, use the estimated probability and expected rate of return to price the bond.

Assumed that a one-year catastrophe risk bond with a par value of F and a coupon rate of c is issued. The interest payment date is whether the loss index reaches the trigger level accounting date. The payment of the principal due depends on whether the loss index exceeds the trigger level. When the trigger level is reached, the issuing company has the right to confiscate part or all of the principal and interest when the bond expires, which is:

When $0 \leqq t < T$, $V_T = 0$

When $t = T$, $V_T = \begin{cases} A \times F, & L \geq D \\ F \times (1 + c), & L < D \end{cases}$

Where V_T is the amount that should be received by the investor on the due date. A indicates the par value repayment ratio at maturity. D is the trigger level.

Therefore, the catastrophe bond price calculation equation can be represented as the discounted expected value of the yield to maturity, namely:

$$V = e^{-rT} \times \left[F \times (1 + c) \times Pr_{(L<D)} + A \times F \times Pr_{(L \geq D)}\right] \tag{6}$$

This article designs a one-year zero-interest agricultural catastrophe bond with relatively simple structure. The bond price is expressed as:

$$V = e^{-rT} \times \left[F \times Pr_{(L<D)} + A \times F \times Pr_{(L \geq D)}\right] \tag{7}$$

Under the condition of no arbitrage opportunity, the price of the catastrophe bond depends on the discount rate r of the bond, the par value F, the matured par value reimbursement ratio A, the trigger level D, and the tail distribution of the fluctuation index X.

3 Empirical Research

3.1 Data Source

In this article, we take Fuji apple of China as an example for empirical research. Taking the monthly wholesale market price from January 2008 to December 2018 as experimental data, we designed a one-year zero-interest agricultural product price catastrophe bond product and conducted an exploratory study on the pricing of catastrophe bonds. Original data source from the Department of Market and Information Technology of the Ministry of Agriculture and Rural Affairs of the People's Republic of China and the National Bureau of Statistics of China.

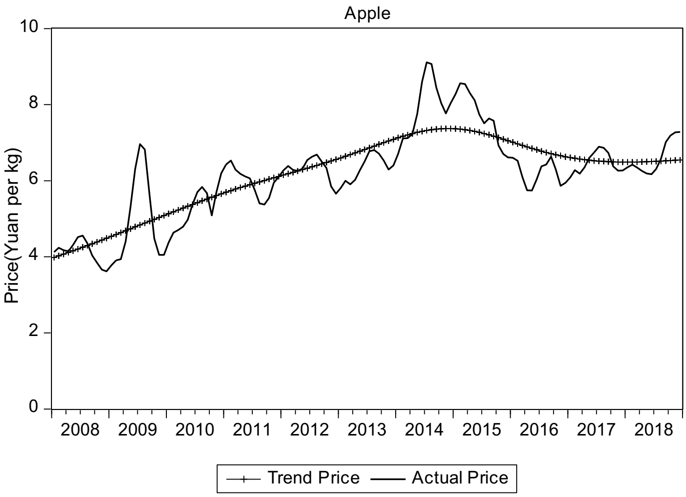

Fig. 1 The actual price and trend price of apple

3.1.1 Construction of Apple Price Fluctuation Sequence

Firstly, utilize the CPI to revise the apple price nationwide, then apply the H-P filtering decomposition. Prior to the application of the H-P filtering, the price is break down with Census-X12 method into sequences of trend cycle items, seasonal items, and irregular elements. This article applied multiplication model to represent seasonal elements with relative numbers, which can avoid the influence of measurement units and enhance the comparability between different economic variables. Next apply the H-P filtering method to get the trend price for the trend cycle item, as shown in Fig. 1. Then agricultural product price fluctuation sequence is obtained according to (1).

3.1.2 Fitting the Tail Distribution of Apple Price Fluctuation Sequence

In the process of POT model fitting in the agricultural product price fluctuation sequence, the selection of the threshold u in the model is the premise of accurately estimating the scale parameter σ and the shape parameter ξ, and is crucial for the effectiveness of the POT model. If the selected threshold too high, the sample data used for analysis will be too little, and the variance of the estimated parameters is too high. However, if the selected threshold is too low, though the data used for the analysis will be greater, but the asymptotic behavior of the model is not satisfied and hence resulting in a biased estimation. Currently, the academic community usually adopts the mean residual life plot to determine the threshold. Previous studies have shown that if the average residual life graph after a certain value tends to be linear, then the value is the threshold of the sample. According to the Mean Residual Life Plot of apple price fluctuation sequence, as shown in Fig. 2 and the different thresholds, the

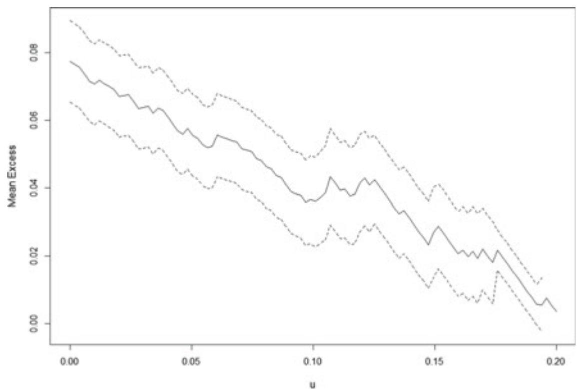

Fig. 2 Mean residual life plot of apple price fluctuation sequence

scale parameter σ and the shape parameter ξ change, as shown in Fig. 3, the threshold is determined to be 0.10.

There are many methods for estimating the GPD distribution parameters, such as the maximum likelihood estimation method, the moment method and the probability weight moment method. The most used method is the maximum likelihood estimation method, mainly because it is progressively normalized. Normally distributed, allowing an approximation of the standard error and confidence interval. In this article, the maximum likelihood estimation was applied to obtain the scale parameter σ estimated value of the GPD distribution is 0.04915 and the shape parameter ξ estimated value is −0.34249.

The most commonly applied inspection for the extreme value distribution model is the empirical probability plot (P-P plot), the quantile plot (Q-Q plot), the Return Level Plot, et al. Theoretically, the P-P diagram and the Q-Q diagram should be

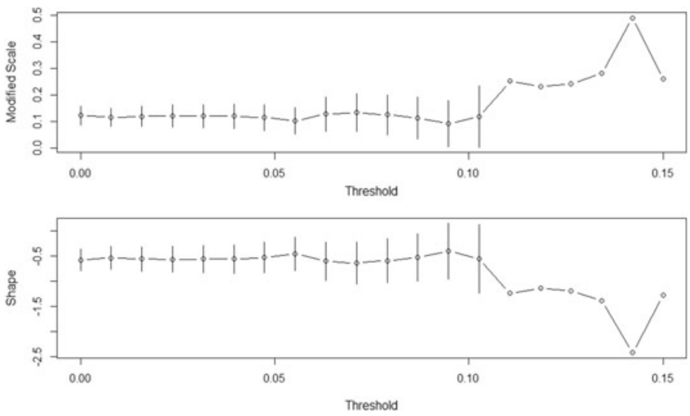

Fig. 3 Variation of scale parameter σ and shape parameter ξ under different thresholds

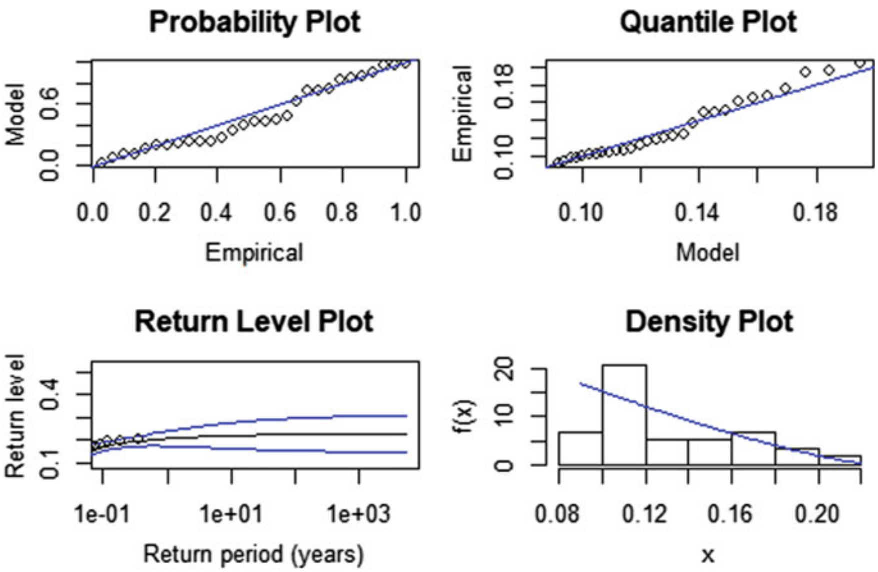

Fig. 4 The tail distribution fitting diagnostic plot of apple price fluctuation sequence

approximated as a straight line. It means that the selected distribution function is not suitable if the graph deviates seriously linearly. It is important to point out that the judgment of P-P and Q-Q diagrams depends on individual experiences and preferences. The distribution fitting inspection can be further applied to evaluate the model in order to be more accurate in the consideration of the suitability of the model. As seen from the distribution fitting diagnosis Fig. 4 that the points on the P-P plot and the Q-Q plot are basically on the diagonal line and from the probability density plot, the distribution function estimation and the frequency plot fitting are also relatively better. We can see from Fig. 4 there are four plots, they are probability plot, quantile plot, return level plot and density plot. It can be seen from the four plots that the fitting effect is good.

Therefore, the probability distribution function of the tail portion of the apple price fluctuation sequence that measures the catastrophe risk is:

$$F(x) = 1 - 0.18939 \times \left(1 - 0.34249 \times \frac{x - 0.10}{0.04915}\right)^{\frac{1}{0.34249}} \tag{8}$$

3.1.3 Calculating Catastrophe Bond Price of Apple Price

According to the probability distribution function of the tail distribution of apple price fluctuation sequence (8) and the function of one-year zero-interest bond (7),

Table 1 Catastrophe bond prices under different bond parameters

Rate of return r (%)	Repayment ratio A (%)	Bond price
7.5	0	92.24
	50	92.50
	100	92.77
10	0	89.96
	50	90.22
	100	90.48
12.5	0	87.74
	50	87.99
	100	88.25

under the condition of the catastrophe bond parameters (the value needs to be within a reasonable range). The parameters for the one-year zero-coupon bond pricing are set as below:

- The Par value F of the bond is 100 yuan;
- The trigger level D is the percentage of the price fluctuation, and the trigger value is set to 20% according to the fluctuation sequence;
- The repayment ratio A of the bond's par value ranges from 0 to 1. This article selects three types: principal confiscation, partial reimbursement, and full reimbursement, which are 0, 50, 100%;
- Investors generally demand higher expected returns due to the poor liquidity and low correlation between agricultural catastrophe risk bonds and other financial products. Assuming a one-year bond yield r of 10%, three different necessary rates of return are set to reflect changes in bond prices at different discount rate levels respectively and that are 7.5, 10 and 12.5% since there is no limitation on the rate of return.

According to the combination of the above parameter values, the bond price of the catastrophe bond with a par value of 100 yuan was issued under different circumstances. The results are shown in Table 1. As shown in the table, taking the rate of return is 7.5% as example, when the payment ratio is 0%, the bond price is 92.24 yuan; when the payment ratio is 50%, the bond price is 92.50 yuan; when the payment ratio is 100%, the bond price is 92.77 yuan. When the rate of return remains unchanged, the bond prices increase with payment ratio. The same rule also applies to a 10 or 12.5% return rate. As we can see from the table, when the rate of return is 10 or 12.5%, as repayment ratios increase, the bond prices increase.

3.1.4 Summary

As seen from Table 1, (1) When the face value repayment ratio A is fixed, the catastrophe bond price decreases as the necessary rate of return increases. Because in the case of relatively stable risk-free interest rates, the risk that investors themselves bear increases as the necessary rate of return increases. This allows investors to demand a higher risk premium, which leads to an increase in the bond's real rate of return and a lower bond price. This is consistent with the pricing theory of ordinary bonds. (2) When the rate of return r is fixed, the catastrophe bond price increases as the face value repayment ratio A increases. This is because the higher the face value payout ratio, the more returns investors receive when the trigger event occurs. This indicates that the risk of the bond is small, which result in high bond prices.

4 Conclusion

At present, China lacks an effective catastrophe risk management system for agricultural product prices. China has implemented a government-led catastrophe rescue system all along the way. It is funded by the national finances when a catastrophe occurs and it is a huge financial burden for the country. Agricultural product price catastrophe bonds, as one of the effective ways to spread the risk of agricultural product price catastrophe, combined the insurance market with the capital market, has great significance to relieve the underwriting pressure of the insurance market, enrich the investment channels of investors in the capital market, and reduce the national finance.

In this paper, we design a pricing model for agricultural product price catastrophe bonds, and take empirical research on Fuji Apple in China to calculate the price of catastrophe bonds. Firstly, the fluctuation sequence of apple price is constructed by the deviation degree of actual price and trend price. Then, the POT model in extreme value theory is introduced to fit the tail distribution of apple price fluctuation sequence, and after determining the tail distribution function of apple price fluctuation, the probability of bond being triggered can be accurately calculated. Finally, the pricing model of agricultural catastrophe bonds is used to calculate the price of one-year zero-coupon apple catastrophe risk bonds. The results show that it is feasible to combine the tail distribution function of agricultural price fluctuation series with the interest rate maturity structure of zero-coupon bonds to calculate the prices of agricultural price catastrophe bonds under different bond parameter combinations and realize the pricing of catastrophe bonds. The price of catastrophe bonds is negatively correlated with the required yield and positively correlated with the repayment ratio of face value. The research results of this paper provide the possibility for the application of catastrophe risk bond in agricultural product price catastrophe risk management.

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The Impact of OFDI Reverse Technology Spillover Effect on Industrial Structure Upgrading

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Abstract This paper first analyzes the mechanism and path between the reverse spillover effect and structural upgrades. It is believed that OFDI (Outward Foreign Direct Investment) mainly acquires technology spillovers through R&D (Research and Development) cost sharing, factor R&D absorption and reverse technology transfer, and promotes industrial structure upgrading through four channels: labor mobility, supply and demand structure, technical structure and technological innovation. Then, this paper empirically analyzes this process through specific data and models, and studies the impact of absorptive capacity on the spillover effect of OFDI reverse technology. The results show that the technological progress obtained through OFDI is closely related to the upgrading of industrial structure. Human resources capital stocks, economic development levels, technological levels, infrastructure levels and financial development levels can significantly contribute to the upgrading of industrial structure process. Therefore, in the process of industrial

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transformation and upgrading, China should increase its foreign investment, optimize investment types, investment structure and investment location, and continuously improve human capital investment, and development investment, so as to better promote the upgrading of industrial structure through technology spillovers.

Keywords OFDI reverse technology spillover · Industrial structure upgrade · Absorption capacity

1 Introduction

Since the reform and opening up, China's economic development has achieved remarkable achievements. During this period, traditional industries played an important role in China's economic growth. However, over-reliance on traditional industries has also produced a series of problems, such as overcapacity and serious waste of resources, which have seriously hindered the development of China's economy. At present, China's economy has entered a "new normal", and the traditional factor-driven mode can no longer meet the needs of economic growth. Simply relying on the traditional development model cannot provide lasting momentum for economic development, not can the transformation be delayed. Although China has been optimizing its industrial structure over the past four decades, there are still problems such as slow growth of the industrial structure level index and unreasonable internal structure of the industry. In this context, how to promote the upgrading of industrial structure and provide impetus for economic growth has become an urgent issue.

By investing abroad, especially in developed countries, it is possible to break the restrictions on technology introduction and obtain a series of foreign investment benefits. With the development of China's economy and the acceleration of the "going out" pace, the development of China's outward foreign direct investment is becoming rapidly. In 2016, China's OFDI flows reached US$196.15 billion, up 34.7% year-on-year. Acquiring technology spillovers through OFDI is an important way to promote the upgrading of industrial structure and drive domestic technological progress. Under the background of the current industrial restructuring pressure, researching on the relationship between OFDI reverse technology spillover and industrial structure upgrading, and analysis of its absorptive capacity can provide theoretical guidance for China's OFDI policy formulation and accelerate the upgrading of industrial structure. Therefore, this paper uses the data of 30 provinces in China from 2004 to 2016 to construct a fixed-effect model to empirically test the impact of OFDI reverse technology spillover effects on industrial structure upgrading, and further studies the influencing factors of OFDI reverse technology spillover effects.

2 Literature Review

In the study of the spillover effect of OFDI reverse technology, Kogut and Chang found that when Japanese companies invest in the United States, they prefer to obtain advanced technology from US companies in joint ventures, so they speculate that OFDI may have reverse technology spillover effect [1]. Li mainly researched on the pharmaceutical industry and the electronics industry and proposed that the main motivation for cross-border M&A is to enhance its technological competitiveness by acquiring foreign corresponding technologies [2]. Zou found that there is a certain synergy between the expanding of China's OFDI and the improvement of total factor productivity. However, due to the current small scale of OFDI and unreasonable investment structure, the government should reasonably guide foreign investment [3]. Chen, Li and Shapiro argued that developed countries can attract a large amount of investments in emerging market countries, because they need to use these investments to acquire knowledge and technology to achieve their own rapid growth [4].

In the research of OFDI reverse technology spillover effect and industrial upgrading, foreign scholar Chang studied the Japanese electronic industries' OFDI in the United States and found that after investing in Japan, learning advanced technology through the "learning by doing" model, which in turn enhances its own competitiveness [5]. Driffiel and Love found that technology-acquired outward foreign direct investment can obtain technological spillover, thereby promoting the optimization of industrial structure [6]. Domestic scholars Pan and Yuan divided China's outward foreign investment into market-seeking OFDI, resource-seeking OFDI and technology-seeking OFDI according to different investment motives, and empirically analyzed that technology-seeking OFDI play more obvious role in industrial upgrading [7]. Wang and Han conducted empirical research using China's provincial panel data from 2003 to 2015, and concluded that the OFDI reverse technology spillover effect can promote industrial structure optimization by promoting domestic technological progress [8]. This conclusion is consistent with the study of Nie, Xu and Liu [9].

In the study of absorptive capacity of the country, Cohen and Levinthal first proposed the concept of "absorption capacity" and argued that the stronger the absorptive capacity of enterprises in foreign direct investment, the stronger the reverse technology spillover effect [10]. Subsequently, domestic and foreign scholars studied the factors influencing the absorptive capacity of the country to explain the difference in reverse technology spillover effects. Olofsdotter specifically divided absorptive capacity. He believed that population growth rate, economic openness, and infrastructure level would have an impact on the reverse technology spillover effect of OFDI [11]. Li found that both human capital and R&D investment could influence the spillover effect of OFDI reverse technology, and the effect of R&D investment intensity is stronger [12]. Wang and Gui studied the effects of OFDI reverse technology spillover effects on technological innovation in the eastern, central and western regions [13]. They found that technological innovation in all three regions could produce positive technology spillover effects.

In summary, the impact of OFDI reverse technology spillover effects on industrial structure upgrading has attracted extensive attention and research from scholars at home and abroad. Compared with the existing research, this paper supplements and expands the existing research from the following aspects: first, the setting method based on the classic model is appropriately enriched. Based on Wang' s basic research model, this paper introduces six proxy variables to analyse the role of absorptive capacity and realize the enrichment of existing research. Second, the selection of factors influencing the upgrading of industrial structure [8]. While using OFDI reverse technology spill over as the main explanatory variable, we introduce the level of openness, human capital, R&D investment intensity, foreign direct investment and infrastructure level as control variables, and then provide corresponding suggestions by analysing the impact of these variables on industrial structure upgrading. Third, it enriches the selection range of the absorptive proxy variables. Using six agent variables, such as human capital, R&D investment intensity, economic development level, technology level, infrastructure level, and financial development level, we can more comprehensively examine which variables can be used as absorptive capacity.

3 Research Design

3.1 Measurement Model Setting

Coe and Helpman first proposed international R&D spillover model. They believed that a country could make full use of foreign direct investment and import trade activities, acquire important international resources such as advanced foreign technology and management experience, and transfer them in the home country to promote domestic technological progress [14]. They set the model as follows:

$$LnF_t = C + \beta_1 LnS_t^d + \beta_2 LnS_t^m + \varepsilon_t \tag{1}$$

Among them, Ft is on behalf of the total factor productivity of investor country, Sd and Sm represent the R&D capital stock obtained through domestic R&D and import trade respectively, t is time, ε is error.

Further, scholars Lichtenberg and Pottelsberghe revised the C-H model and proposed L-P model to introduce the international R&D capital stock obtained by OFDI into the model [15]. The final model is as follows:

$$LnF_t = C + \beta_1 LnS_t^d + \beta_2 LnS_t^m + \beta_3 LnSL_t^{ofdi} + \varepsilon_t \tag{2}$$

In view of the availability of data and the feasibility of research, this paper is based on the L-P model and the model set by Wang [8]. With the industrial structure upgrading index as the dependent variable, the R&D capital stock produced by outward foreign direct investment as the main independent variable, and the external opening level, human capital, R&D investment intensity, foreign direct investment and infrastructure level as control variables. The basic measurement model is constructed as follows:

$$\begin{aligned} LnISO_{it} = {} & C + \beta_1 LnS_{it}^{ofdi} + \beta_2 LnHR_{it} + \beta_3 LnOP_{it} \\ & + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \alpha_i + \varepsilon_t \end{aligned} \tag{3}$$

Among them, ISO_{it} is the industrial structure level index, S_{it}^{ofdi} is the reverse technology spillover of OFDI, HR_{it} is the stock of human capital, OP_{it} is the degree of opening up to the provinces, RD_{it} is the intensity of R&D investment, FDI_{it} is the amount of foreign direct investment, INFit is the status of infrastructure, α_i is individual fixation effect, ε is the error term.

Secondly, this paper introduces human capital, R&D investment intensity, economic development level, technology level, infrastructure level and financial development level as the agent variables of absorptive capacity into the model, and tests whether the different absorptive capacity will has an impact on the OFDI reverse technology spillover effect through the cross-term model. The new model form is constructed:

$$\begin{aligned} LnISO_{it} = {} & C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * lnI_{it} + \beta_2 LnHR_{it} + \beta_3 LnOP_{it} \\ & + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \beta_7 lnI_{it} + \alpha_i + \varepsilon_t \end{aligned} \tag{4}$$

3.2 Indicator Selection and Data Description

This paper refers to the research of Pan and Yuan and measures the industrial structure upgrade with the industrial structure level index [7]. The measurement formula used is:

$$ISO_{it} = 1 * Y_{1it} + 2 * Y_{2it} + 3 * Y_{3it} \tag{5}$$

Y_{it} represents the proportion of the output value of the first, second and third industries in the gross domestic product, the closer ISO_{it} to 3, indicating the higher the level of industrial structure is.

S_{it}^{ofdi} represents the foreign capital stock of outward foreign direct investment in each province, to measure the reverse technology spillover of OFDI. Considering the representativeness of the sample and the availability of the data, this paper selects seven countries and regions in the world with relatively concentrated R&D resources and close contact with China's OFDI as the research object. At the same time, referring to the practice of Chen et al. [16], the paper introduces foreign R&D spillover formula obtained through outward foreign direct investment:

$$S_t^{ofdi} = \sum \frac{OFDI_{jt}}{Y_{jt}} * S_{jt}^{rd} \tag{6}$$

$OFDI_j$ represents China's OFDI stock in country j, Y_j is the GDP of country j; S_j^{rd} is the stock of R&D capital of country j. Then, according to the province's OFDI stock accounted for the national OFDI stock share, calculating the foreign capital stock obtained by each province through outward foreign direct investment, the formula is

$$S_{it}^{ofdi} = \frac{OFDI_{it}}{\Sigma\, OFDI_{it}} * S_t^{ofdi} \tag{7}$$

S_{it}^{ofdi} is the foreign capital stock of outward foreign direct investment in each province, $OFDI_{it}$ represents OFDI stock in each province.

Control variables: (1) HR_{it} for the human capital stock, referring to the years of education proposed by foreign scholars Barro and Lee [17], measured by the average years of education in each province, the formula is:

$$HR_{it} = HR_{it}^1 * 6 + HR_{it}^2 * 9 + HR_{it}^3 * 12 + HR_{it}^4 * 16 \tag{8}$$

HR_{it}^1, HR_{it}^2, HR_{it}^3, HR_{it}^4 is the proportion of the number of educated students in primary schools, junior high schools, high schools and universities is the total number of people respectively.

(2) OP_{it} is for the degree of openness to the outside world, referring to the study of Fu, Ye and Wang, which is measured by the ratio of the import and export trade volume of each province to the gross domestic product [18]. (3) RD_{it} is for the R&D investment intensity, referring to the practice of Li, calculated by the ratio of R&D investment and GDP of industrial enterprises above designated size in each province [12]. (4) FDI_{it} is the actual use of foreign investment in each province. (5) INF_{it} is for the status of infrastructure, referring to the practices of Wang Man and Zhang Shuo [19], measured by the number of highway miles in each province; ε is the error term.

The technical level TE_{it} refers to the practice of Wang, measured by the number of patent applications in each province [8]. The economic development level GDP_{it} is based on the research of Wang Lei and Gui Chengquan, measured by the per capita GDP of each province [13]. The financial development level FIN_{it} refers to the study of Kan [20], measured by the ratio of the loan balances of financial institutions to GDP.

The specific data of this section are mainly derived from: the statistical yearbook of each province, "the Statistical Bulletin of China's Outward Foreign Direct Investment", "the International Statistical Yearbook", the World Bank Database, "the China Business Yearbook", "the China Statistical Yearbook", "the China Labor Statistics Yearbook", "the China Science and Technology Statistical Yearbook" and so on.

4 Empirical Results and Analysis

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4.1 The Impact of OFDI Reverse Technology Spillover Effect on Industrial Structure Upgrading

(1) *Hausman test*

This paper selects the data of 30 provinces in China (Tibet is excluded because the proportion of direct investment in foreign investment is too low) from 2004 to 2016 as the research object. Considering the length of panel data and other factors, the panel is mainly processed by static estimation method. In order to avoid the deviation of the regression result caused by the model setting error, this paper first adopts F test and Hausman test before returning to the basic model, testing the basic model's setting form and determining the best model form.

Firstly, the F statistic obtained by the F test is 38.28, and the probability is 0.0000 < 0.01. Therefore, the null hypothesis can be rejected at the 1% significance level, that is, there is reason to think that the fixed effect model is better than the mixed effect model. Secondly, the Hausman statistic value is 23.27, and the probability is 0.0015, which is significantly less than 0.01, so the null hypothesis that the random effect model is better than the fixed effect model can be rejected.

(2) *Empirical test result*

Considering the above two situations comprehensively, this paper uses the fixed effect model to empirically analyze the panel data. First, the fixed effect regression is performed on the model by using stata12.0, and the following Table 1 is obtained. In addition, because the absorption and conversion of technology may need to take some time to be completed, the reverse technology spillover effect obtained by OFDI may have hysteresis [21]. Therefore, this paper selects OFDI reverse technology spillover lag phase one and lag phase two respectively as the explanatory variable. Then regressing the model and using the results as the robustness test, this paper further verify the impact of the OFDI reverse technology spillover effect on the industrial structure upgrade. The regression results are compared with the benchmark model's result. As shown in Table:

According to the regression results, we can get the following conclusions: first, the regression coefficient of the core variable OFDI reverse technology spillover is 0.25, and the significance test at the 1% level is passed, indicating that for every 1% increase

Table 1 The regression results and robustness test results of model (3)

Testing method	The benchmark model	Lag phase one	Lag phase two
Variables	*lnISO*	*lnISO*	*lnISO*
$\ln S^{ofdi}$	0.247***		
	(0.0479)		
$\ln S^{ofdi}_{t-1}$		0.253***	
		(0.0521)	
$\ln S^{ofdi}_{t-2}$			0.315***
			(0.0578)
lnHR	0.152**	0.156**	0.0849
	(0.0587)	(0.0675)	(0.0715)
lnOP	−0.102***	−0.0953***	−0.0857***
	(0.0266)	(0.0272)	(0.0274)
lnRD	0.283***	0.273***	0.235***
	(0.0655)	(0.0734)	(0.0829)
lnFDI	−0.0971*	−0.126**	−0.160**
	(0.0542)	(0.0594)	(0.0640)
lnINF	−0.0678	−0.0826	−0.0450
	(0.0484)	(0.0610)	(0.176)
Constant	−2.70e−07	0.0525***	0.121***
	(0.0145)	(0.0183)	(0.0421)
Observations	390	360	330
R-squared	0.542	0.522	0.522
Number of new province	30	30	30

Standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

in S^{ofdi}, the industrial structure upgrade index will increase by 0.25%. In addition, as control variables, the regression coefficients of human capital stock and R&D input intensity are positive, and are significant at 5 and 1%, respectively. Among them, the regression coefficient of human capital stock is 0.15, which means that for every 1% increase of human capital, the industrial structure level will increase by 0.15%, and the regression coefficient of R&D input intensity is 0.28, indicating that for every 1% increase in R&D investment, and the industrial structure level will increase by 0.28%. The coefficient of openness is negative, and the significance test at the 1% level is passed, indicating that the higher the degree of opening up, the more unfavourable the upgrading of industrial structure is. The possible reason is that in China's current foreign trade, service trade still lags behind commodity trade. Therefore, foreign trade has a limited role in promoting the tertiary industry, but it is more conducive to promote the development of the secondary industry. The coefficient of foreign direct investment is also negative, and the level of significance is low, indicating that FDI is negatively correlated with the upgrading of China's industrial structure. To a certain extent, it will inhibit the upgrading and optimization of industrial structure, but the inhibition is weak. The possible reason is that the foreign direct investment attracted by China is not evenly distributed in the three industries, and most of them are invested in the secondary industry, which is not conducive to China's industrial structure upgrading. The regression coefficient of the infrastructure level is negative, and it has not passed the significance test, indicating that the level of infrastructure in various regions of China does not affect the upgrading of industrial structure.

At the same time, it can be seen from Table 1 that the regression results obtained by using the OFDI reverse technology spillover lag phase 1 or the lag phase 2 as explanatory variables have no substantial changes with the regression results of the benchmark model, which indicates that the results of the measurement model are robust. The reverse technology spillover effect of OFDI can indeed promote the upgrading of industrial structure. In addition, the regression coefficients of lnSofdit-1 and lnSofdit-2 are 0.25 and 0.32, respectively, indicating that compared with the current period, the impact of outward foreign direct investment technology spillover on the upgrading of industrial structure in the later period may be greater. It also shows that the impact of OFDI on the upgrading of industrial structure has no lag effect, that is, enterprises can obtain technology spillovers through OFDI. After a period of absorption and transformation, the promotion effect on industrial structure upgrading may be stronger.

4.2 The Factors Affecting the Absorptive Capability of OFDI Reverse Technology Spillover

In view of the absorption capacity analysis of the OFDI reverse technology spillover effect, this study attempts to identify relevant factors that promote the spillover effect of OFDI reverse technology. Thereby introducing human capital stock, R&D investment intensity, economic development level, technology level, infrastructure level. With the financial development level as the proxy variables and the OFDI reverse technology overflow variable, the interaction term is formed. The interaction terms in the model (4) have six construction methods, the formulas are as follows:

$$\begin{aligned} LnISO_{it} = {} & C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * LnHR_{it} + \beta_2 LnHR_{it} \\ & + \beta_3 LnOP_{it} + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \alpha_i + \varepsilon_t \end{aligned} \tag{9}$$

$$\begin{aligned} LnISO_{it} = {} & C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * LnRD_{it} + \beta_2 LnHR_{it} \\ & + \beta_3 LnOP_{it} + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \alpha_i + \varepsilon_t \end{aligned} \tag{10}$$

$$LnISO_{it} = C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * LnGDP_{it} + \beta_2 LnHR_{it} + \beta_3 LnOP_{it} + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \beta_7 LnGDP_{it} + \alpha_i + \varepsilon_t \tag{11}$$

$$LnISO_{it} = C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * LnTE_{it} + \beta_2 LnHR_{it} + \beta_3 LnOP_{it} + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \beta_7 LnTE_{it} + \alpha_i + \varepsilon_t \tag{12}$$

$$LnISO_{it} = C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * LnINF_{it} + \beta_2 LnHR_{it} + \beta_3 LnOP_{it} + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \alpha_i + \varepsilon_t \tag{13}$$

$$LnISO_{it} = C + \beta_1 LnS_{it}^{ofdi} + \theta LnS_{it}^{ofdi} * LnFIN_{it} + \beta_2 LnHR_{it} + \beta_3 LnOP_{it} + \beta_4 LnRD_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINF_{it} + \alpha_i + \varepsilon_t \tag{14}$$

(1) *Hausman test*

Consistent with the above empirical analysis steps, this study first tested the model setting form using the F test and the Hausman test. The results showed that the six expressed F test statistic and Hausman test statistic were significantly less than 0.01. Therefore, it is reasonable to assume that the mixed effect model and the random effect model should be abandoned, and the fixed effect model should be used to empirically analyze the absorption capacity of the OFDI reverse technology spillover.

(2) *Empirical test result*

In this paper, Stata 12.0 is used to regression the setting models to test the influence of different factors on the absorption capacity of the OFDI reverse technology spillover effect. In addition, the interaction item can be multi collinear with the main item. In order to avoid this problem, the interaction items are centrally processed, and then the measurement model is used to regress the processed models, which makes the results more credible. The final regression results are shown in Table 2 below:

Table 2. The regression results and robustness test results of model (4)

Variables	(9)	(10)	(11)	(12)	(13)	(14)
	lnISO	*lnISO*	*lnISO*	*lnISO*	*lnISO*	*lnISO*
lnS^{ofdi}	0.237***	0.250***	0.235***	0.171***	0.244***	0.202***
	(0.0471)	(0.0480)	(0.0740)	(0.0584)	(0.0478)	(0.0451)
lnHR	0.170***	0.138**	0.0752	-0.00275	0.174***	−0.0137
	(0.0578)	(0.0599)	(0.0649)	(0.0634)	(0.0597)	(0.0600)

(continued)

Table 2. (continued)

Variables	(9)	(10)	(11)	(12)	(13)	(14)
	lnISO	*lnISO*	*lnISO*	*lnISO*	*lnISO*	*lnISO*
lnOP	−0.0863***	−0.0968***	−0.0772***	−0.0825***	−0.0993***	−0.0591**
	(0.0264)	(0.0269)	(0.0264)	(0.0259)	(0.0265)	(0.0255)
lnRD	0.240***	0.300***	0.195***	0.207***	0.282***	0.289***
	(0.0652)	(0.0671)	(0.0667)	(0.0645)	(0.0653)	(0.0614)
lnFDI	−0.108**	−0.100*	−0.0883*	−0.141***	−0.112**	−0.0510
	(0.0532)	(0.0542)	(0.0534)	(0.0528)	(0.0546)	(0.0509)
lnINF	0.00791	−0.0605	0.0230	−0.0469	−0.0969*	0.0214
	(0.0515)	(0.0488)	(0.0561)	(0.0481)	(0.0508)	(0.0468)
$clnS^{ofdi}$ _clnHR	0.0669***					
	(0.0176)					
$clnS^{ofdi}$ _clnRD		0.0190				
		(0.0168)				
$clnS^{ofdi}$ _clnGDP			0.0784***			
			(0.0169)			
$clnS^{ofdi}$ _clnTE				0.0521***		
				(0.0163)		
$clnS^{ofdi}$ _clnINF					−0.0404*	
					(0.0222)	
$clnS^{ofdi}$ _clnFIN						0.0646***
						(0.0170)
lnGDP			0.0833			
			(0.0955)			
lnTE				0.338***		
				(0.0833)		
lnFIN						0.165***
						(0.0296)
Constant	−0.0432**	−0.0109	−0.0657***	−0.0422**	−0.00476	−0.0246
	(0.0182)	(0.0175)	(0.0201)	(0.0192)	(0.0147)	(0.0150)
Observations	390	390	390	390	390	390
R-squared	0.560	0.544	0.569	0.580	0.546	0.604
Number of new province	30	30	30	30	30	30

Standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

According to the regression results, we can draw the following conclusions: among the six influencing factors we selected, the regression coefficients of the interaction terms of human capital stock, economic development level, technical level, financial development level and OFDI reverse technology spillover are positive and significant at the level of 1%. This indicates that these four variables can have a significant impact on the absorption capacity of OFDI reverse technology spillovers. The cross-item of infrastructure level and S^{ofdi} passes the 10% significance test, but the significance is weak and the coefficient is negative. The possible reason is that the infrastructure construction is often more conducive to the development of the secondary industry, but the indicator for measuring the upgrading of industrial structure is that the proportion of the primary, secondary and tertiary industries increase in turn. So it may not reflect its role as an absorptive capacity. However, the R&D input intensity and the $S_s^{ofdi'}$ cross-term regression coefficient is small, and the significance test is not passed, indicating that the R&D input intensity does not affect the relationship between the OFDI reverse technology spillover and the industrial structure upgrade. This is consistent with the findings of Chen [16]. She found that in the process of studying China's OFDI reverse technology spillover effect and its production conditions, R&D investment did not promote the reverse technology spillover effect of OFDI. The possible reason is that enterprises tend to invest R&D expenditures in its own R&D level, rather than the technology transfer from abroad. At the same time, we also notice that although the regression results of the human capital stock cross-terms and other influencing factors are significant, the regression coefficients are smaller than the regression coefficient of S^{ofdi}, indicating that China's current human capital, technology level, economic development level and financial development level are still relatively low and has not been fully utilized their roles as an absorptive capacity.

Similarly, in this paper, the lag period of the OFDI reverse technology spillover effect and the six influencing factors form a cross-term, respectively, and the robust test is conducted. The main research conclusions of Table 2 are unchanged, indicating that the regression results of the model (4) are robust.

5 Research Conclusions and Policy Recommendations

In summary, this paper takes the relationship between China's OFDI technology spillovers and industrial structure as the research perspective, and combines literature review, current situation analysis, mechanism analysis and empirical analysis to comprehensively analyze the impact of OFDI on China's industrial structure upgrading. China' s OFDI technology spillovers provide a way to obtain advanced foreign technology. The research results show that: OFDI can indeed improve the technical level of the industry through technology spillover, and is an effective way to promote industrial upgrading. At the same time, this impact also has a certain lag, that is, the technology spillover obtained in the current period can also be applied to the later industry. The expansion of human capital stock scale and the increase of

R&D investment intensity will also have a positive impact on the upgrading of industrial structure, while the relationship between FDI and China's industrial structure upgrading is negatively correlated. In terms of absorptive capacity, domestic human capital stock level and economic development level, the technical level, infrastructure level and financial development level are the main factors affecting the industrial structure upgrading effect of China's outward foreign direct investment reverse technology spillover. However, due to the relatively low level of development of various influencing factors in China, these factors have not fully played the role of absorptive capacity.

Based on the research conclusions, this paper puts forward the following suggestions: first, while providing policy support and encouraging private enterprises to "go global", it is necessary to rationally optimize the investment industry and regional layout to adapt it to the industrial upgrading strategy. In terms of investment industry, it is essential to increase the outward foreign investment of the manufacturing industry. On the one hand, it is indispensable to promote the strategic investment of the domestic manufacturing industry, transfer excess domestic production capacity, optimize resource allocation, and release sufficient resource space. On the other hand, it is necessary to combine with the actual situation of domestic industrial upgrading to encourage technology-intensive enterprises to carry out outward foreign investment in leading countries, and provide the follow-up support for technology absorption and transformation. In the investment area, it is needful to expand the investment area and scope. On the one hand, encourage enterprises to invest in the areas such as Africa that are relatively backward development and abundant resources, transfer excess domestic production capacity, and make full use of local resources. On the other hand, it is essential to increase investment in developed countries with advanced technologies and use technology spillover effects to acquire core elements such as technology.

Second, in order to promote the upgrading of industrial structure and fully release the spillover effects of acquired technologies on the home country, it is necessary to start from the absorption capacity and improve the efficiency of technology absorption and application. On the one hand, strengthen the investment in domestic R&D and personnel training. It is indispensable to continuously improve the level and quality of high-tech fields, actively introduce foreign high-tech talents, guide the communication between domestic and foreign experts, fully learn to use the advanced equipment and technical means of the invested countries, realize the transnational flow of research and development elements, and carry out international R&D cooperation. On the other hand, it is needful to actively establish a mature financial system, consolidate the economic foundation, and provide the regional financial system and economic level with the necessary financial support and financing support for outward foreign direct investment, so that enterprises could have sufficient strength to absorb the acquired technology and improve the efficiency of industrial structure upgrade.

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Determinants of Acquisition Premium: A Pre and Post Comparative Study of Pakistan and China

Hameeda Akhtar, Faryal Arif Chishtie, and Syed Zulfiqar Ali Shah

Abstract Analyzing the determinants of acquisition premium with objective to maximize the shareholder's wealth. It is also necessary to study the pre and post-acquisition firm factors under the target of Pakistani and Chinese equity market. This paper uses the empirical model to test the determinants of acquisition premium and evaluate the impact of acquisition on firm factors in emerging market of Pakistan and China. In order to comply with the rules of optimal acquisition premium and deciding acquisition for sustainability of firms this paper applies the ordinary least square and also uses the generalize method of moments technique to estimate the firm factors between pre and post-acquisition. Therefore the objective of this paper is to know what are determining factors of acquisition premium and how acquisition effect firm factors in Pakistani and Chinese equity market.

Keywords Acquisition premium · Pre and post-acquisition · Ownership concentration · Independent directors · Profitability

1 Introduction

In recent years firms are paying their attention on acquisition. The basic goal of a corporate firm is to reach highest, prestige and powerful position. In order to achieve mile stones, firms take alternative approach for instance organic and inorganic growth strategy. Corporate firms increase productivity, develop new products, enter the new market, reduce production cost and increase output is organic growth strategy.

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Compliance with inorganic growth strategy, firms achieve asset growth and sales expansion through merger, acquisition, divestitures, and takeover etc.

Merger and acquisition is interesting topic for researchers due to its importance in the corporate world. This strategy is followed excessively by developed than developing countries. In United States and European market, most of firms perform acquisition. Therefore research in this area is very common for developed markets. Acquisition strategy is less practiced in Pakistan. Hence, in this context fewer literatures are found. Determinants of acquisition premium and comparative study in nonfinancial sector are not discussed yet in this field. Therefore, this study analyzes the determinants of acquisition premium. It also empirically tests the impact of acquisition on firm factors in listed nonfinancial firms of Pakistan and China.

The objective of this study is to estimate determinants influencing the acquisition premium and compare firm factors in nonfinancial sector of Pakistan and China. The significance of this study is defined in different ways. In this domain most of the studies conducted in banking sector of Pakistan [1]. Some researchers focused only textile sector [2]. There is no comparative study done on firm factors before in Pakistan. Findings on acquisition premium are not present in former research of Pakistan. These are the points contributing to the previous literatures of merger and acquisition.

2 Literature Review

2.1 Determinants of Acquisition Premium

In determinants of acquisition premium, the firm size gives market power, political connections and high operating performance in the weak governed market as they pay less acquisition premium [3]. Previous literature studies the impact of liquidity on acquisition, method of payment and performance following acquisition. Acquisition accomplished by cash payment reduces long-term and short term performance. High cash firms are most likely involve in acquisition. Firms with high growth opportunity do not prefer cash payment. It is most dominant in financially constrained firms who face opportunity cost. The findings also explain the impact of firm size on acquisition premium examine by [4]. The experience (that is experience prior to merger and acquisition and early venture capital backed experience) of acquirer firms positively affects acquisition of private target firms operating in information technology sector. Experience also enables firms to better deal with acquisition premium [5]. The impact of firm listed age is negative on acquisition premium [6]. Merger and acquisition influence innovative activities and firm size. Large merger and acquirer firms continue innovative efforts and produce output over time. Merger and acquisition transform small non innovator to active innovator firms [7]. It shows that cash flows affect the acquisition premium to perform acquisition for innovation. Female directors carefully perform acquisition by paying optimal amount of acquisition premium.

Such acquisition increases post-acquisition firm value [8]. It means firm cash flow is an integral part for acquisition premium decision. Celebrity CEOs (Chief executive officers) pay smaller acquisition premium but deviation in performance motivates them to pay higher acquisition premium. Increase in celebrity status, also increases the acquisition premium, further it reduces post-acquisition performance [9]. Independent directors are paid with compensations which motivate them for effective monitoring and selecting optimal acquisition premiums [10]. Prior study examines the research and development investment made by target firm. In this case acquirer acquires target firm with research and development through debt financing. It in return increases the acquisition premium [11]. It also specifies less tangible acquirer firm acquires new technology with high acquisition premium. Firms use stocks to get high deal returns. In firms, effective ownership structure brings synergy and high long term performance [12]. The difference between the offer price and the market value of target firm in pre-acquisition period is defined as acquisition premium. Past researchers contributed to the literature on determinants of acquisition premium. Determinates are information asymmetry, financial performance of acquirer, and celebrity status of CEO. They focus on over and underpaid CEO effect on acquisition premium. They find that underpaid CEO increase its output and choose acquisition to increase its wealth. They make compensation equitable with outer referents. Therefore they pay high acquisition premium for deal completion [13].

2.2 Pre and Post Acquisition Analysis

According to several studies acquisition effect firm factors they are firm size, asset growth, profitability, cash flows, and tangibility positively as well as negatively. For instance, Acquirers select bigger and less profitable target firms. They pay high acquisition premium and enter the transaction during recession. It reflects lower post-acquisition profitability and high leverage. It also shows reduction in post-acquisition firm size [14]. Previous literature studies the effect of merger and acquisition activity on acquirer's firm value. The sample includes 65521 merger and acquisition deals from 2000 to 2010 in technology, energy, communication and utility industries. They use ratio of enterprise value to earnings before interest, tax, depreciation and amortization. They find negative medium run merger and acquisition effect on firm value. They also find instantaneous positive effect on firm value because of fast moving of enterprise value. It explains the firm value which also affects firm cash flows in post-acquisition period [15]. Past study collected sample during period of 2005 to 2012 on merger and acquisition deals from financial and nonfinancial sector of Pakistan. Their study proves that firms focus on size rather value maximization. Those managers who are overconfident in controlling targets they pay high acquisition premium [16]. Manager's decision results into negative post-acquisition cash flows. In accordance with the merger and acquisition theory, successful acquisition increases the acquirer firm performance by improving efficiency [17]. Past study examine the effect of acquisition on financial performance. Data collected for five years using financial ratios. They find no significant impact of acquisition on financial performance [18]. Managers of acquiring firm pay higher premium to foreign targets when risk on failing to achieve synergy is lower [19]. Acquisition gives synergy to the firms. Synergy increases firm size in post-acquisition period. The impact of Merger on research and development intensity and profitability of top companies is positive. The impact on research and development is both for long and short term. Its impact on profitability is positive only for long term [20]. Merger and acquisition for acquiring technology positively related to firm performance. There is positive significant impact of firm growth, size and age on profitability after performing acquisition. It shows merger and acquisition impact firm growth and firm growth influence performance [21]. Figure 1 describes determinants as independent variables and acquisition premium as dependent variable. Figure 2 represents acquisition as independent variable and firm factors as dependent variables.

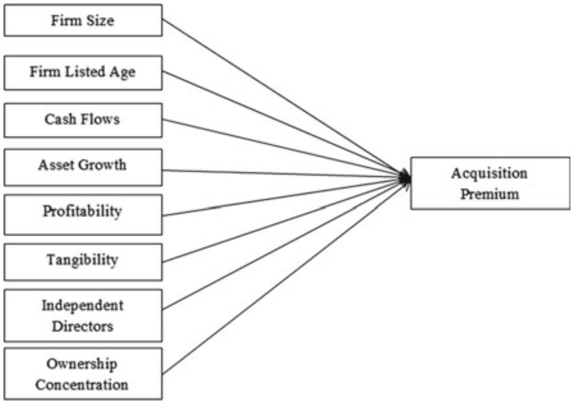

Fig. 1 Determinants of acquisition premium

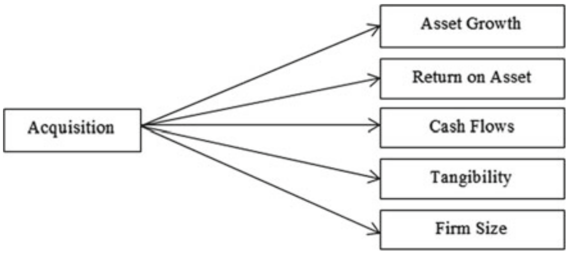

Fig. 2 Impact of acquisition on firm factors

3 Methodology and Data

Current study applied ordinary least square for determinants of acquisition premium. The standard OLS is a simplest technique and also confirmed the validity of assumption by using Breusch-Pagan-Godfrey test of heteroscedasticity, Breusch-Godfrey Serial Correlation LM Test and Wald Test of Endogenity.

Generalize method of moments is used to investigate the impact of acquisition on firm factors. GMM estimation technique is essential for dynamic panel data model used in this paper. In dynamic panel data model independent variable depend on its lag value. The study also used System GMM estimation technique as it takes additional instruments to resolve the problem of serial correlation, heteroscedasticity, endogeneity, omitted variable bias and measurement error. Sargan test verified the instrument's validity. Therefore these techniques are best considered for empirical analysis.

This paper took 120 nonfinancial public acquirers and targets from Pakistani and Chinese equity market from 2007 to 2016. Data on 22 nonfinancial listed acquirers each from Pakistani and Chinese equity market were collected from 2005 to 2016. The study took data from Pakistan stock exchange, competition commission of Pakistan, yahoo finance, Shanghai stock exchange and Shenzhen stock exchange, financial statement analysis of nonfinancial sector firms published by the state bank of Pakistan, annual reports of Chinese firms and RESSET database. The study used three years pre and post-acquisition data to empirically test the impact of acquisition on firm factors in Pakistani and Chinese equity market. Determinates of acquisition premium are firm characteristics and governance structure. Previous study takes multiple determinants of acquisition premium in Chinese equity market. Some studies researched on supply and demand for acquisition target, resource characteristics, chief executive officer characteristics and information asymmetry between investors and acquirer firms. Pertaining to existing research this study research on firm and governance characteristics as determinants because they play important role in determining acquisition premium. This study constructed various model for pre and post-acquisition analysis by altering independent variables and control variables. Dependent variables are asset growth, return on asset, cash flows and tangibility. It also includes control variables to confirm the robustness and remove profitability. Model specification includes lag dependent variable to analyze its effect on dependent variable other than acquisition event.

3.1 Impact of Firm Factors on Acquisition Premium

This study estimated econometric model to test the determinants of acquisition premium. The determinants are: firm size, firm listed age, cash flows, asset growth, profitability, tangibility, independent directors and ownership concentration. APR = acquisition premium, FS = firm size, FLA = firm listed age, CF = cash flows, ROA = return on asset, TANG = tangibility, AG = asset growth, ID = independent directors, OC = ownership concentration. β_0 is intercept. The sign and coefficients $\beta_1, \beta_2, \beta_3, \ldots.., \beta_8$ explain the positive and negative effect of acquirer firm factors on acquisition premium in acquisition deals, Where i is individual firm, t is time and ε_t is error term.

$$\begin{aligned} APR_{it} = &\beta_0 + \beta_1(FS)_{it} + \beta_2(FLA)_{it} + \beta_3(CF)_{it} \\ &+ \beta_4(ROA)_{it} + \beta_5(TANG)_{it} + \beta_6(AG)_{it} \\ &+ \beta_7(ID)_{it} + \beta_8(OC)_{it} + \varepsilon_{it} \end{aligned} \tag{1}$$

3.2 Impact of Acquisition on Firm Factors

To accomplish the second objective, this paper estimate several models by taking different independent variables. It also includes control variables to avoid multi-collinearity problem. This study takes three years pre and post-acquisition of firm size, asset growth, cash flows, profitability and tangibility in the Pakistani and Chinese equity by following the methodology of [22]. In this case, the acquisition is a dummy variable, considering 0 for pre-acquisition and 1 for post-acquisition period. β_0 is intercept. The signs and coefficients $\beta_1, \beta_2, \beta_3, \ldots\ldots., \beta_6$ explain positive and negative impact of acquisition on firm factors. Where i is individual firm, t is time, εt is error term and it-1 is the lag year effect.

$$\begin{aligned} AG_{it} = &\beta_0 + \beta_1(Acquisition)_{it} + \beta_2(AG)_{it\text{-}1} + \beta_3(CF)_{it} \\ &+ \beta_4(ROA)_{it} + \beta_5(FS)_{it} + \beta_6(TANG)_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

$$\begin{aligned} ROA_{it} = &\beta_0 + \beta_1(Acquisition)_{it} + \beta_2(ROA)_{it\text{-}1} + \beta_3(CF)_{it} \\ &+ \beta_4(FS)_{it} + \beta_5(TANG)_{it} + \beta_6(AG)_{it} + \varepsilon_{it} \end{aligned} \tag{3}$$

$$\begin{aligned} CF_{it} = &\beta_0 + \beta_1(Acquisition)_{it} + \beta_2(CF)_{it\text{-}1} + \beta_3(AG)_{it} \\ &+ \beta_4(ROA)_{it} + \beta_5(FS)_{it} + \beta_6(TANG)_{it} + \varepsilon_{it} \end{aligned} \tag{4}$$

$$\begin{aligned} TANG_{it} = &\beta_0 + \beta_1(Acquisition)_{it} + \beta_2(TANG)_{it\text{-}1} + \beta_3(FS)_{it} \\ &+ \beta_4(AG)_{it} + \beta_5(ROA)_{it} + \beta_6(CF)_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

4 Results

In results section, Table 1 shows the negative and significant impact of cash flows on acquisition premium which is consistent with past literature. They find that in financial crises firms pay high acquisition premium due to information asymmetry. In the presence of CEO they can reduce acquisition premium by their network, expertise and control [23]. It means acquirer's CEO of high cash flow firms pay lower acquisition premium. The effective governance structure of high cash flow acquirer firms lead them to pay less acquisition premium. Return on assets and tangibility has positive and significant impact on acquisition premium. According to previous literature CEO hubris negatively affects financial performance. This effect is mitigated in the presence of board vigilance. CEO power strengthens the negative effect of CEO hubris on firm performance. It means over confident CEO of high profitable and tangible firms are paying high acquisition premium [24]. The study shows negative and significant impact of ownership concentration on acquisition premium. It explains that strong governance of acquirer firm pays less acquisition premium in comparison to weak governance of the target firm [12].

Results also show the insignificant impact of firm size and asset growth. This insignificant effect is due to the stock market effect. Stock price of liquidated target firm creates an opportunity of less acquisition premium for acquirer firm. It exhibit firm size and asset growth are not significant indicators of acquisition premium.

Firm listed age is also positive and insignificant with acquisition premium. It is again due to market effect. Positive news on share price and high valuation of target

Table 1. OLS regression analysis to test the impact of firm-specific factors on acquisition premium

Dependent variable: acquisition premium		
Variables	Coefficient	p-value
Firm size	−0.001	0.902
Firm listed age	0.001	0.791
Cash flows	−0.151	0.076*
Return on asset	1.737	0.013**
Tangibility	0.118	0.096*
Asset growth	−0.037	0.692
Independent directors	−0.001	0.54
Ownership concentration	−0.002	0.084*
Constant	0.079	0.704

The table shows determinants of acquisition premium in which cash flows, return on asset, tangibility, and ownership concentration are significantly influencing acquisition premium decision. The insignificant variables are firm listed age, asset growth, and independent directors. After running regression analysis R^2 is 0.125. *, **, *** are for 10, 5 and 1% level of significance firm agree both parties to pay a high acquisition premium which indicates insignificant impact of firm listed age on acquisition premium. In past studies corporate governance is highly appreciated by investors in the stock market as they make stocks attractive for investor which justifies the insignificant effect of independent directors on acquisition premium [25]. The R-square is the coefficient of determination. It means model brings 12.5% variation in acquisition premium.

Findings in Table 2 show negative and significant effect of the acquisition on asset growth in Pakistani and Chinese equity market. Previous researchers study the impact of merger and acquisition on research and development spending growth and its intensity. They find negative and significant effect of merger and acquisition on research and development intensity. It is due to sharp increase in sales. It means acquisition drop down expenditure on research and development which identifies reduction in the development of technology. Hence, it also leads to reduction in post-acquisition asset growth [26].

Table 3 exhibit the positive and significant impact of the acquisition on firm profitability (return on asset) in Chinese equity market. According to past literature, contribution of credit rating significantly influences merger and acquisition. It improves acquirer firm performance as their presence force firms to pay fair acquisition premium and maximize the post-acquisition firm performance. Profitability of acquirer firms increases in post-acquisition period [27].

This table also indicates the insignificant impact of acquisition on return on asset in Pakistani equity market [28].

It further explains that firm is unable to get advantage from acquisition strategy because there are some important factors missed by non-financial firms following the acquisition. Factors may be higher employee turnover and lack of acquisition practice.

Table 2. System GMM results for the impact of acquisition on asset growth in Chinese and Pakistani equity market

Dependent variable: asset growth				
Variables	China		Pakistan	
	Coefficient	p-value	Coefficient	p-value
Acquisition	−0.231	0.029**	−0.091	0.0377**
Asset growth it-1	−0.060	0.589	0.003	0.943
Firm size	−0.019	0.741	0.042	0.247
Return on asset	1.343	0.216	1.455	0.000***
Cash flows	−0.127	0.632	−0.285	0.000***
Tangibility	−1.175	0.003***	−0.087	0.23
Constant	1.043	0.418	−0.535	0.373
Sargan (p value)		0.998		0.99

This table shows negative and significant impact of acquisition on asset growth after controlling firm size along other independent variables. *, **, *** are for 10, 5 and 1% level of significance

Table 3. System GMM results for the impact of acquisition on return on asset in Chinese and Pakistani equity market

Dependent variable: return on asset				
Variables	China		Pakistan	
	Coefficient	p-value	Coefficient	p-value
Acquisition	0.042	0.058**	−0.164	0.259
Return on asset it-1	0.137	0.039**	0.392	0.006***
Firm size	−0.006	0.184	0.045	0.037**
Asset growth	0.018	0.203	0.136	0.000***
Cash flows	0.054	0.027**	0.047	0.133
Tangibility	−0.021	0.646	−0.122	0.008***
Constant	0.146	0.114	−0.614	0.094*
Sargan (p value)		1.00		0.961

Impact of acquisition on return on assets is significant only in Chinese equity market. In Pakistani equity market its impact is insignificant. *, **, *** are for 10, 5 and 1% level of significance

Table 4. System GMM results for the impact of acquisition on cash flows in Chinese and Pakistani equity market

Dependent variable: cash flows				
Variables	China		Pakistan	
	Coefficient	p-value	Coefficient	p-value
Acquisition	−0.001	0.982	−0.392	0.005***
Cash flows it-1	−0.128	0.232	0.147	0.056**
Tangibility	0.561	0.003***	−0.111	0.428
Asset growth	−0.095	0.237	−0.409	0.000***
Firm size	0.069	0.01***	0.021	0.516
Return on asset	1.258	0.008***	0.998	0.026**
Constant	−1.642	0.006***	0.070	0.899
Sargan (p value)		0.997		0.946

In this table acquisition is insignificant with cash flows in Chinese equity market. Return on asset and tangibility are significant with cash flows in Chinese equity market. In Pakistani equity market acquisition, asset growth and return on asset have significant impact on cash flows. *, **, *** are for 10, 5 and 1% level of significance

Table 4 result shows that acquisition does not significantly influence cash flows [29]. According to past literature there are other factors like pre acquisition firm growth, size, and assets are factors influencing cash flows in post-acquisition period. Acquisition is not an actual indicator of cash flows. Poor implementation of acquisition process is also one of the reasons for insignificant result.

Table 4 also shows the negative and significant impact of acquisition on cash flows. In previous literatures, increase in passive ownership increases CEO power with fewer independent directors. This result causes negative effect on firm value

Table 5. System GMM results for the impact of acquisition on tangibility in Chinese and Pakistani equity market

Dependent variable: tangibility				
Variables	China		Pakistan	
	Coefficient	p-value	Coefficient	p-value
Acquisition	−0.039	0.063*	0.038	0.422
Tangibility it-1	0.454	0.000***	−0.086	0.113
Asset growth	−0.020	0.537	−0.021	0.478
Firm size	0.045	0.000***	0.096	0.000***
Return on asset	−0.411	0.045**	0.231	0.112
Cash flows	0.137	0.008***	−0.042	0.033**
Constant	−0.862	0.000***	−1.255	0.000***
Sargan (p value)		0.990		0.983

There is significant impact of acquisition on tangibility in Chinese than in Pakistani equity market. In both markets cash flows and firm size significantly influence firm tangibility.

in the presence of higher agency cost in post-acquisition period. Hence, Cash flow deteriorates significantly in post-acquisition period [30].

Table 5 explains the negative and significant impact of acquisition on tangibility. It is consistent to past findings. Study examines the impact of merger and acquisition on research and development in the presence of increasing and decreasing in house and external research and development. Their result shows negative and significant impact of merger and acquisition on in house and external research and development. Merger and acquisitive does not contribute to research and development sourcing strategy but it can achieve lower cost and higher efficiency. It shows that firm is unable to get a technological asset which leads to negative post-acquisition tangibility [31].

Results in this table also represent the insignificant impact of acquisition on firm tangibility in Pakistani equity market. According to past literatures, insignificant result is because upward and downward movement of economy or country specific factors such as demand, supply and credit condition impacts the firm value and also effect the adjustment of tangible assets [32]. Sargan test is used for instrument validity. *, **, *** are for 10, 5 and 1% level of significance.

5 Conclusion

This study empirically tests the determinants of acquisition premium and also examines the impact of acquisition on firm factors in Pakistani and Chinese equity market during period 2007 to 2016. The determinants of acquisition is empirically tested by ordinary least square, while the study analyze impact of acquisition on firm factors by generalize method of moments during period 2005 to 2016.

The results indicate that cash flows, return on asset, tangibility and ownership concentration significantly impact the acquisition premium. Firm size, Firm listed age, asset growth and independent directors insignificantly impact the acquisition premium. The impact of the acquisition on asset growth is negative and significant in Pakistani as well as in Chinese equity market. The impact of acquisition on return on asset is positive and significant in the Chinese equity market. The impact of acquisition on Cash flows is negative and significant in Pakistani equity market. Acquisition influence tangibility negatively and significantly only in Chinese equity market.

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The Evolution of Marine Industrial Structure Based on Macro-Micro Analysis

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Abstract The influence of marine economy in the economic and society of coastal countries is becoming more and more significant, and the changes in the marine industrial structure will bring a series of impacts on the social and economic development. By analyzing the relationship between marine industrial structure and industrial efficiency, the feedback model of industrial efficiency—industrial structure is established. According to the evaluation method of marine industry efficiency and the DEA model of super efficiency, the evaluation index of input and output efficiency of marine industry is screened, and the change process of marine industry efficiency in the 2001–2017 years is calculated and combined with industrial knot. The evolution process of marine industry is analyzed, and the changing path of industrial efficiency in the evolution of marine industrial structure is expounded. It is found that during the last 20 years, the evolution process of marine industrial structure can be divided into three main stages, namely, the extensive development period of the marine industry, the period of structural adjustment, the period of the development of the new kinetic energy of the marine industry, with the significant difference in the fluctuation of the marine productivity in the different periods of the evolution of the industrial structure. Sign. Finally, according to the development trend of marine industry, we put forward suggestions for the development of marine industry.

Keywords Marine economy · Industrial efficiency · Industrial structure · Evolution

1 Introduction

With the transformation of international marine industry, China's marine industry is facing both international and domestic challenges while becoming a pillar industry of the country. The diversity of marine industry is determined by the sea-related nature of marine industry. Marine economy in modern sense includes a variety of production

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activities for the development of marine resources and relying on marine space, as well as industrial activities for the development of marine space and resources. The economic aggregation formed by such industrial activities is classified as the category of modern marine economy, including marine transportation industry and marine fishery. Marine salt industry, marine shipping industry, coastal tourism, marine oil and gas industry, etc. The complexity of marine industrial structure makes the impact of the change of marine industrial structure on social and economic development a series of [1]. The research on the trend and analysis of the change of marine industrial structure is becoming an important issue of concern to researchers.

In the study of the changing trend of marine industrial structure, different experts interpret the inherent law of the development and change of marine industry from multiple perspectives. They mainly include three aspects. First, some researchers pay attention to the concentration of marine industry and think that the gap between subdivided industries will be narrowed continuously [2]. Second, they analyze the causes and mechanism of spatial differences [3], from maturity [4], industrial structure. In the aspect of contribution degree, it is reasonable to analyze the matching relationship between the change of marine industrial structure and the growth of marine economy. Thirdly, using the analysis of the efficiency of marine industry, it explains the changing law of marine industry and marine economy in different dimensions, calculates the contribution rate of production factor input by spatial econometric method, and explains that the adjustment of marine industrial structure is the result of the growth of marine economy in the medium level. Search for sustained momentum for ocean economic growth.

From the perspective of the change of industrial efficiency, this paper calculates the change of marine industrial efficiency by constructing the efficiency model of marine industry, and then analyses the evolution law of marine industrial structure in the development of marine economy. The purpose is to re-explain the changing process of marine industry efficiency and summarize the internal law of marine industry evolution under the two dimensions of national macro-data and industrial data.

2 Analysis of Marine Industrial Structure and Industrial Efficiency

In the existing research on marine industry, researchers interpret the structure of marine industry from two aspects: industry distribution dimension and spatial distribution dimension. In terms of spatial distribution, it is found that there are some problems in the spatial distribution of marine industry in China, such as uncoordinated development among regions, low development concentration and obvious development isomorphism [5]. By analyzing the regional disparities of marine economic development in different times and the changing trend of spatial agglomeration of marine industry, this paper explores the influencing factors and explores the spatial spillover effect with the help of Moran's I index [6]. There are also studies on the evaluation score of the development level of modern marine industry through variable fuzzy identification model, and the dynamic evolution trend of modern marine industry is analyzed by Kernel density estimation.

In the dimension of industry distribution, based on VES production function [7] or grey relational degree [8], the researcher establishes an estimation model with marine industrial structure as a threshold variable to explore the impact of changes in marine industrial structure on marine economic growth, and finds that the impact of changes in marine industrial structure on marine economic growth is significantly different. Some researchers take the marine industry system as the research sample and select the land industry as the reference frame to demonstrate the uniqueness of the marine industry in terms of the demand for industrial factors from the aspects of development speed, labor productivity, comparative labor productivity, inter-industry correlation intensity and so on.

With the fluctuation of economy and the progress of technology, the industrial structure of the ocean is evolving continuously. Through the existing research, it can be found that there is a multi-channel feedback cycle between the industrial structure and the industrial efficiency of the ocean. The change of the efficiency of marine industry is the macroscopic expression of the change of efficiency of marine enterprises, and the change of enterprise efficiency directly affects the spatial distribution of enterprises in marine industry. The change of the spatial agglomeration mode of marine industry can change the proportion of competitiveness among different marine industries in the region, thus leading to the overall change of the marine industrial structure (Fig. 1).

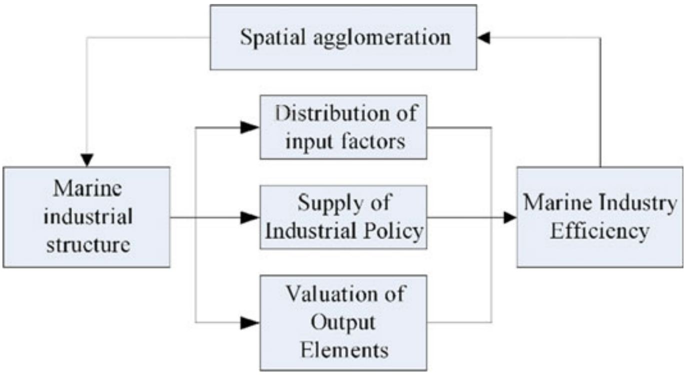

Fig. 1 Feedback cycle of marine industrial structure and marine industrial efficiency

3 Establishment of Efficiency Evaluation Method and Model for Marine Industry

Industrial efficiency is an efficiency analysis method which regards industry as a decision-making unit. It focuses on the development process of industry in the whole social and economic environment. In the existing research on the efficiency of marine industry, researchers have taken DEA method as an important measure of the efficiency of marine industry. Some researchers have constructed the method and index system of single-factor comparative analysis and total-factor comprehensive quantitative evaluation of regional marine industry competitiveness evaluation, which can comprehensively evaluate the competitiveness of marine industry from the level of competitive factors and provincial level. Some researchers use the method of entropy to construct the index to measure the green total factor productivity of marine economy under the dual factors of resources and environment. Based on the Tobit model of panel data, the effects of different factors on the green total factor productivity of marine economy are investigated.

In the process of regional marine industry operation, decision-makers can be defined from two aspects: time dimension and space dimension. From macro dimension, Zhao Lin and other existing studies measure the marine economic efficiency of 11 provinces and municipalities along the coast of China from 2001 to 2012 based on the SBM model considering unexpected output and Malmquist productivity index model. On this basis, the evolution stage and mechanism of China's marine economic efficiency are analyzed [9]. On the medium dimension, there are also studies on the changes of the efficiency of the marine industry in the region with enterprises as the object. Cheng Na's DEA analysis of listed companies with different types of holding in the marine secondary industry shows that non-state-owned holding companies are involved in the marine industry. Operating efficiency is higher than that of state-owned holding. In this paper, in order to obtain the correlation between the internal and external environment of the region and the efficiency of marine industry, combined with the input-output data of national and provincial regional industries, the operational efficiency of regional marine industry is deeply analyzed, the promotion policies and development environment of marine industry are analyzed, and the change trend of the efficiency of regional marine industry at the meso-level is obtained by using the super-efficiency DEA model. Potential, and through the analysis of its causes for the development of marine industry to provide theoretical recommendations.

4 Evaluation Index of Input and Output Efficiency of Marine Industry

The selection of input-output indicators of marine industry depends on the general production process of marine industry. In the existing studies, some studies measure the marine economic efficiency of different provinces and municipalities in different years based on the SBM model and Malmquist productivity index model considering unexpected output. There are also studies that use the super-efficiency DEA window model to evaluate the input-output efficiency of marine science and technology in different coastal provinces and cities over the years, so as to get the relationship between the increase of the input-output efficiency of marine science and technology and the improvement of management level and the optimization of scale [10]. In the process of analyzing the efficiency of marine industry, in order to measure the development trend and change characteristics of the marine economy as a whole, it is necessary to search for similar parts in the production process of different marine industries. In this study, in order to study the differences of operational efficiency of marine industry in different situations from macro and meso aspects, the S-DEA method is used as the main research method to estimate the input-output efficiency. The applicability of the S-DEA method is improved according to the differences between the input-output index and the enterprise-level index in macro-regions, so as to obtain the technical efficiency and scale efficiency of each comparative unit. Rate, and further analysis of the characteristics of marine industry and development direction.

4.1 Selection of Samples and Indicators

Taking the input-output data of the national marine industry from 2000 to 2016 as an example, this paper firstly chooses the data of the national marine industry from 2001 to 2017 as the input-output variable and the year as the decision-making unit, and then evaluates the efficiency trend of the development of the marine industry at the macro level. Secondly, it chooses the data of the listed companies of the national marine industry from 2001 to 2017 as the input-output variable. The change of efficiency of marine industry at micro level is analyzed.

In the efficiency estimation model of marine industry, the selection of input-output indicators should follow the three principles of availability, accuracy and comprehensiveness. Firstly, from the perspective of availability and accuracy, it is more reliable to include indicators related to the development of marine industry in the marine statistical yearbook and bulletin. Secondly, the selected input-output data can reflect the development of marine industry comprehensively. The main production processes of regional marine industry. Specifically, from the perspective of investment in marine industry, it is mainly divided into three parts: human capital investment, capital investment and environmental construction investment. Human capital investment refers to the total human capital of the personnel participating in marine industry. In this paper, the number of industrial employees can be selected as the agent variable, capital investment can be used as the agent variable, and environmental construction investment is the agent variable. It refers to the extensive investment in environmental renovation and facilities construction for marine industry, which includes the policy preferential measures for promoting marine museums, museums and other facilities

Table 1 National marine industry macro-efficiency evaluation system

Index	X1	Employment in marine industry
	X2	Total assets of marine industry
	Y1	Added value of marine industry
	Y2	Proportion of gross marine product to gross domestic product

Table 2 Microeconomic efficiency evaluation system of national marine industry

Index	X1	Number of employees in enterprises
	X2	Total assets of enterprises
	Y1	Total business revenue
	Y2	Total profit of enterprises

and improving the registered business environment of marine enterprises. Its agent variable can choose the number of registered enterprises in marine industry.

The output of marine industry mainly includes economic benefit output, which is similar to the output evaluation of other industries. The economic benefit of marine industry can be expressed in two aspects: its industrial output and its proportion in regional total industrial output. The development level of marine industry is represented by the total output of marine industry, the added value of marine industry and the total profit of marine enterprises. The contribution of marine industry to the economy is represented by the contribution rate of national economy. Therefore, combined with the availability and accuracy of data, through the collation of relevant data, the regional marine industry operational efficiency evaluation index system is shown in Tables 1 and 2.

At the micro-data level, we select the micro-research samples of private listed companies, and calculate the micro-level efficiency of marine industry by analyzing the input-output data of Listed Companies in the marine economy area from 2001 to 2017. In this way, we take enterprises as decision-making units and use panel data of all enterprises in the time period as the whole sample to calculate the efficiency, and obtain the data of each enterprise in the past years. Then, by comparing the average value of enterprise efficiency over the years, we analyze the changing trend of efficiency of China's marine industry.

The annual financial data of all listed companies of marine industry in Shanghai and Shenzhen Stock Exchanges from 2001 to 2014 are selected as the research basis. The data sources are Guotai'an Financial Research Database and the annual reports of listed companies. The basic information is as follows (Table 3).

4.2 Data Sources and Processing

(1) *Labor input.* Ocean industry practitioners refer to all persons who work in ocean and related industry organizations sponsored or managed by the marine

Table 3 Overview of marine industry enterprises in China

Year	Number of marine economic enterprises	Average number of employees	Average total assets (millions)	Average gross revenue (millions)	Average gross profit (millions)
2001	11	402.3	527.6	229.2	14.4
2002	11	645.3	870.1	455.1	17.8
2003	11	888.3	1165.1	506.1	31.7
2004	13	957.2	1290.7	675.2	26.5
2005	13	892.8	1406.1	753.9	−19.9
2006	15	1896.0	1536.0	876.4	20.8
2007	15	1875.7	1764.6	1181.1	92.9
2008	15	1854.3	2055.4	1355.6	77.8
2009	22	1705.2	1902.4	1093.3	66.2
2010	32	1624.6	2250.5	1136.4	108.8
2011	36	1882.8	2606.1	1414.8	68.9
2012	37	1943.0	2831.5	1637.2	51.6
2013	37	1919.4	3197.6	1836.8	5.0
2014	41	1990.9	3572.2	2083.4	222.0
2015	41	2110.6	4174.2	2299.6	68.4
2016	47	2248.7	4842.6	2588.7	167.5
2017	48	4266.8	5860.2	3874.3	234.4

sector and non-marine industry organizations sponsored by the marine sector and obtain remuneration for their work. The data come from China Ocean Statistical Bulletin. The number of employees involved in the sea is selected as the index of labor input, while the total number of employees is selected at the micro level of enterprises. Labor input.

(2) *Capital input.* This paper uses "the stock of marine economic capital" as the index of capital input. Because there is no relevant statistical data on marine fixed assets investment, the stock of marine capital is estimated from the data of capital investment in coastal areas.

(3) *Enterprise output.* Net profit and turnover are selected as the output indicators of the enterprise. When the net profit index is negative, according to the principle of consistency, the negative net profit is converted into the increased investment of capital in proportion, and then used to calculate the efficiency of enterprises.

5 Relevance Analysis Between Efficiency Measurement Results of Marine Industry and Industrial Structure Evolution Process

From the above model, the national marine industry in 2001–2017 is taken as the decision-making unit, and the linear programming problem in DEA model is solved by MATLAB. The input-output efficiency of China's marine industry in each year is shown in the table below (Table 4).

It can be found from the publication that the operational efficiency of marine industry shows a trend of fluctuating growth in 2001–2017. According to the calculation results of BCC-DEA, the marine industry has achieved relative DEA efficiency in 2001, 2002, 2006, 2007 and 2017, which indicates that after many industrial adjustments, the efficiency of input and output of marine industry has been significantly improved, and industrial efficiency has been gradually improved after 2017. With the rapid development of marine industry, its comprehensive efficiency has been improved year by year.

In the results of BCC-DEA model, the efficiency of five years at the forefront of production is indistinguishable, but comparing the results of super-efficiency DEA, we can find that there are differences among the five effective years of DEA. In the

Table 4 Evaluation of macro input and output efficiency of national marine industry

Year	SDEA	Crste	Yrste	Scale	
2001	1.071	1	1	1	–
2002	1.070	1	1	1	–
2003	0.921	0.921	0.966	0.954	irs
2004	0.945	0.945	0.963	0.981	irs
2005	0.970	0.97	0.973	0.997	irs
2006	1.008	1	1	1	–
2007	1.011	1	1	1	–
2008	0.999	0.999	1	0.999	drs
2009	0.937	0.937	0.942	0.995	irs
2010	0.973	0.973	1	0.973	drs
2011	0.978	0.978	0.984	0.994	drs
2012	0.954	0.954	0.954	0.999	irs
2013	0.961	0.961	0.963	0.999	irs
2014	0.974	0.974	0.975	0.998	irs
2015	0.988	0.988	0.988	1	–
2016	0.989	0.989	1	0.989	drs
2017	1.104	1	1	1	–

Data Source Calculations of this study

effective years of DEA, the highest super-efficiency year is 2017, which is significantly higher than the efficiency values of 2001 and 206, indicating that the marine industry has experienced "twelve years". After the fifth and thirteenth five-year plan and construction of marine industry, the integration level and innovation ability of the whole industry have been significantly improved. Driven by strategic emerging industries, the economic growth of marine industry has been transformed from extensive growth to high-quality growth, and the kinetic energy of industrial operation has been transformed.

Among the non-DEA effective units, there has been a certain degree of scale and technical inefficiency in every year after 2006, which indicates that the process of structural adjustment within the industry has been continuously adjusted, and gradually approached the effective state in the whole process of "12th Five-Year Plan" and "13th Five-Year Plan" construction. With the economic growth and the expansion of the industrial scale, the process of 2008–2015 is becoming more and more effective. The scale of China's marine industry has been adjusted iteratively. In the initial stage, the scale of the marine industry fluctuated. With the increase of new momentum input, the scale of the marine industry has been expanded with high quality, and then gradually achieved scale effectiveness. The expansion of the external market has also led to a new motivation for the expansion of the scale of the marine industry. This cycle lasted until 2017, with the implementation of the marine industry promotion policy for many years, the scale development of the marine industry exceeded the expansion of market volume. The marine industry experienced a temporary decline in returns on scale, but soon with the cooling of the marine industry and the sustainable development of the external market, the marine industry entered a new scale validity period.

In the analysis and calculation of enterprise efficiency, the efficiency distribution of each enterprise in 2003/2006/2012/2017 is calculated separately. Through the analysis and calculation, it can be found that the efficiency difference between enterprises in 2003 is significantly greater than that in 2017 in the year of high overall industrial efficiency in the whole country, while the efficiency difference between enterprises in 2006 and 2012 shows trend change, scale effect respectively. The increasing of enterprises with decreasing rate shows that in the process of changing industrial efficiency, the scale economy of enterprises has gradually appeared bottleneck (Table 5).

6 The Change Path of Industrial Efficiency in the Evolution of Marine Industrial Structure

Since the 21st century, with the rapid economic development, China's marine industrial structure is continually changing. According to the data of China Marine Economic Statistics Bulletin, the gross output value of China's marine industry broke through the 1 trillion-yuan barrier for the first time in 2003, reaching 10.77 billion yuan. The added value of the marine industry was 44.554 billion yuan. According

Table 5 Efficiency distribution of marine enterprises in 2003

Name	SDEA	Crste	Yrste	Scale	
China Phoenix	3.83	1.00	1.00	1.00	–
Dalian International	0.62	0.62	1.00	0.62	drs
Wahlap	0.62	0.62	1.00	0.62	irs
American Capital Holdings Limited	0.11	0.11	0.54	0.21	irs
Blackened shares	0.47	0.47	0.52	0.90	irs
Hualong group	0.29	0.29	0.47	0.61	irs
Shuang Liang	1.81	1.00	1.00	1.00	–
Hengtong photoelectric	0.82	0.82	0.94	0.88	irs
Zhongtian technology	0.40	0.40	0.58	0.70	irs
Beihai	0.53	0.53	0.85	0.63	irs
Changan information	1.54	1.00	1.00	1.00	–

to the comparable price, it increased by 9.4% over the previous year, and continued to grow faster than the national economy in the same period, equivalent to 3.8% of the national gross domestic product. The proportion of the three marine industrial structures is 28:29:43. By 2017, the national gross marine product will be 7761.1 billion yuan. Among them, the added value of marine primary industry will be 360 billion yuan, the added value of secondary industry will be 309.2 billion yuan, and the added value of tertiary industry will be 4391.9 billion yuan. The proportion of the added value of marine primary, secondary and tertiary industries in the gross marine product will be 4.6, 38.8 and 56.6%, respectively. They have all improved significantly.

Analyzing the process of continuous adjustment and development of China's three marine industrial structures since entering the new century, we can find that there are significant differences between China's marine industrial structure and the adjustment of the overall economic industrial structure of the whole country. The proportion of the secondary industry shows the trend of increasing first and then decreasing, while the proportion of the tertiary industry gradually becomes the marine industry after a period of adjustment. Major components. In the past 20 years, the evolution of marine industrial structure can be divided into three main stages. The first stage is the extensive development of marine industry. With the progress of technology and the gradual opening of the domestic market, the secondary industry has been released greatly. This period is the result of the deepening of market-oriented marine economy, with export-oriented and processing-oriented economy as the main industry. The structure provided the main basis for economic development in this period. The proportion of marine secondary industry increased gradually, while the relative proportion of marine tertiary industry decreased year by year. The second stage is the period of structural adjustment. Under the conditions of gradual deep changes in the international and domestic economic structure and increasing environmental pressure, different industries and enterprises in the second and third industries

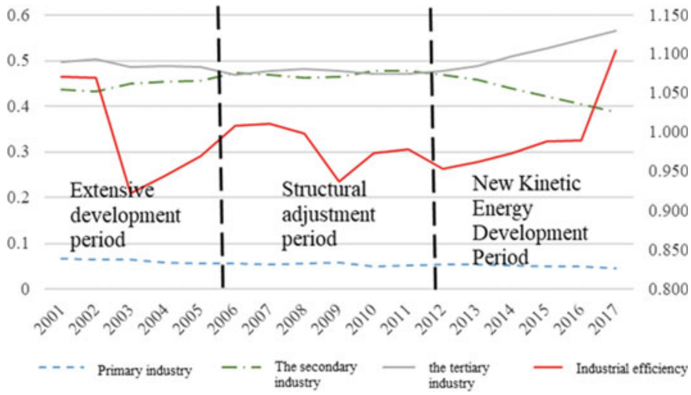

Fig. 2 Trend chart of the adjustment of china's marine industrial structure and the fluctuation of industrial efficiency

of the ocean constantly search for new economic growth points. The marine economy seeks new development directions in the exploration. The proportion of the second and third industries shows an alternating fluctuation trend. The third stage is the new momentum development period of marine industry. Based on the need of coordinated development of marine environment and economy, different regional economic entities gradually explore their new momentum of marine economic development. A number of new industries, new enterprises, new products and new technologies have had a significant impact on the original industrial structure one after another. Correspondingly, the tertiary industry has developed rapidly and its proportion has continuously increased to become the marine industry. The most important component. By comparing the three stages, we can find that the proportion of marine primary industry shows a steady downward trend, while the development of marine tertiary industry is significantly dependent on the changes of the times, and the proportion of secondary industry has a significant negative correlation with the proportion of tertiary industry (Fig. 2).

From the chart, the efficiency of marine industry experienced three fluctuating trends in 2001–2017. Compared with scale efficiency, the pure technical efficiency of industry, i.e. the ratio efficiency of input and output of resources, showed significant differences during the 12th Five-Year Plan and the 13th Five-Year Plan. After eight years of adjustment, the pure technical efficiency of marine industry gradually restored to an effective state during the 13th Five-Year Plan. The fluctuation of efficiency of marine industry mainly comes from the fluctuation of scale efficiency. As mentioned above, with the growth of the whole economic base, the marine industry has been in the cycle of scale efficiency fluctuation and scale efficiency. Until 2017, the scale development of marine industry exceeded the capacity of the economic base, resulting in the decline of scale efficiency, which shows the fluctuation fitting state between the development of marine industry and economic development.

7 Development Trends and Suggestions of Marine Industry

This paper uses SDEA model to measure and analyze the changing trend and evolution characteristics of China's marine industry efficiency and its composition from 2001 to 2017. The feedback model of marine industry efficiency and industrial structure is used to reveal the characteristics of the sequential evolution and staged development of marine industry structure, and then the staged trend of efficiency change is used to explore the main factors affecting the formation of industrial efficiency differences. Based on the structural factors, the following suggestions for the development of marine industry are put forward:

7.1 Systematization and Adaptive Supervision of China's Marine Industry Policy

The marine industrial policy should be geared to the adjustment of the whole marine industrial structure. According to the differences of natural resources, location advantages and marine leading industries in coastal provinces, the responsibilities of marine economic development in each province should be clarified, and the corresponding performance appraisal system should be established. The objectives of marine economic development should be decomposed into the implementation subjects, and the mid-term and final implementation of the green development policy should be compared with the objectives. Assessment and assessment. In order to improve the quality and efficiency of marine economy, we should also intensify the innovation of marine science and technology, establish a complete industrial model of resource utilization, and effectively strengthen marine environmental protection.

7.2 Development Opportunities of Strategic Emerging Industries in the Evolutionary Trend of Marine Industry

The pace of adjustment of China's marine industrial structure is accelerating, the development momentum of marine service industry and marine emerging industries is strong. China's economy is in the stage of "three stages superimposition" of the growth shift period, the painful period of structural adjustment and the early policy digestion period. The pains of structural adjustment are continuing to release. Marine economy also needs to step out of the misunderstanding of traditional extensive development and further optimize and upgrade. Compared with traditional industries, the greatest advantages of marine strategic emerging industries lie in the advantages of high-tech support, good comprehensive benefits, broad market prospects and easy to absorb high-quality labor. In order to seize the critical opportunity period for the development of marine strategic emerging industries, we should start from improving the system and mechanism construction of strategic marine industry development, strengthen cooperation and promote our country. The development of marine strategic emerging industries.

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Simulation on Artificial Stock Market Bubble Based on the Perspective of Investor Behavior

Chao Zheng and Xinyu Cui

Abstract The problem of financial asset bubble has always been the focus of the theory and the industry, and the capital market is one of the important environments. Therefore, analyzing the causes of the stock price bubble and demonstrating the formation mechanism of the stock price bubble plays an important role in preventing financial risks. This paper simulates the artificial stock market including the fundamental investors, the technical investors, the emotional investors and the passive investors, and analyzes the stock price trend, the rate of return, the position of the investors and the rate of return of the account. The results show that the artificial stock market established in this paper can accurately simulate the actual situation of the market, and the results are nearly the same as the empirical research results of the Shanghai Stock Index. When the number of passive investors in the market is small, or the number of fundamental investors is small, or the number of emotional investors is large, stock market bubbles tend to occur and stock price deviates from its value.

Keywords Stock market bubble · Investor behavior · Artificial stock market simulation

1 Introduction

China's capital market has developed rapidly in recent years, especially the growing size of the stock market, but the development of the capital market is accompanied by risks. Price bubble and financial security are important interrelated. The occurrence of capital market risks has micro-foundation. Taking the stock market as an example, many institutions and individual investors participate in it. However, some

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of the participants do not satisfy the full rational assumption, have poor information interpretation ability, and trade at will. The mass chasing ups and downs leads to the impact of market sentiment on the stock price, and the stock price rises to the extent that it is beyond the support of its fundamental level. It creates a price bubble, and when the bubble accumulates to a certain stage, it will burst. And then the stock price drops rapidly, causing heavy losses for investors who don't get out in time. If the bubble is not controlled, it will expand gradually and burst, which will affect the financial security of our country and produce a series of negative effects. Therefore, to test the existence of stock market bubbles, to prevent and defuse capital market risks, to prevent the bread of risks among departments, and to ensure the bottom line of avoiding systematic risk are of great significance to maintain the stability of the capital market and the national financial security.

2 Relevant Literature

The term "bubble" comes from physics and describes the aggregation and breakup of bubbles dispersed in a liquid or solid. In the economic field, people often use the word "bubble" to describe the phenomenon of the continuous rise and fall of asset prices. However, until now, economists have not agreed on the exact definition of the word "bubble". Kindleburger and Aliber believed that a stock bubble was a persistent deviation of stock market prices from the underlying value of listed companies [1]. Meng found the operation of a bubble generally consists of three stages: formation, expansion, bursting or gradual contraction [2]. From this point of view, stock price bubbles can be divided into forward bubbles and reserve bubbles. The forward bubble is higher than the basic value, and the reserve bubble is lower than the basic value. Of course, forward bubble is more common and lethal, and the bursting of Tulip Bubble directly lead to the decline of Netherlands as the world's financial center at that time. if the expectations of investors are taken into consideration, the bubbles can be divided into rational bubble and irrational bubble. Werner believed the rational bubble was those that can still be included in the asset prices based on the assumption that investors have rational expectations [3].

In the early researches on bubble problems, the qualitative method was used, and then the quantitative method was introduced and became the mainstream. At present, there are two kinds of methods to test the existence of bubbles: the indirect method and the direct method, in which the indirect method mainly tests the abnormal fluctuation of asset prices which is different from the hypothesis of random walk, while the indirect method calculates the value of a business and compares it to market prices to determine whether there is a bubble or not.

2.1 The Indirect Method

For example, run tests proposed by Santoni showed that investment bubbles exist if the asymmetry of asset price changes leads to fewer runs of the time series of return than the expected run of the normal return [4]. Mcqueen and Thorley proposed an autocorrelation test, which showed that speculative bubbles exist if the sequence of return on asset prices was first-order autocorrelation [5]. Blanchard and Watson argued that if the Kurtosis of the return was much greater than the Kurtosis of the normal distribution, then there was a speculative bubble [6]. The expansion of the bubble leaded to a smaller positive abnormal return, while the bursting of the bubble leaded to a larger negative abnormal return. The advantages of this method are its simplicity, but its accuracy is limited. Pierdzioch, Risse and Rohloff studied the co-integration of gold and silver prices by using the method of RALS test [7]. They believed that the strength of co-integration relationship between gold and silver changes with time, which reflected the impact of the bubble period and financial crisis. The SADF method, first proposed by Philips, Wu and Yu, was used to test the original level series of prices and dividends [8]. If the test found that the price series has explosive auto-regressive behavior and the dividend series does not, it indicates the existence of explosive rational bubble. Philips, Shi and Yu further proposed the GSADF test, which had the advantage of being more effective for sequences with multiple bubbles in the sample period [9]. Because of the obvious advantaged of the two methods, they had been widely used in recent years.

2.2 The Direct Method

The key problem of direct method is to determine the reasonable basic value of assets, and the price movement that deviates from the value of assets continuously called bubble. In terms of basic value of stock, Norden and Schaller assumed that the logarithmic dividend of stock obeys the first-order random walk process, and then deduced that the basic value of stock in t period is the multiple of the current dividend [10]. This method was used to study the existence of bubbles in Toronto Stock Market. Nneji also used the above-mentioned dividend multiple method to estimate the fundamental value of stocks, and further extracted the stock price bubble based on this [11]. Liu used the improved stock surplus value discount model (FO Model) to calculate the intrinsic investment value and the absolute and relative scale of the stock market bubbles in China at that time [12]. The results showed that compared with the peak of the stock market in June 2001, the absolute scale and relative scale of the stock market bubble in China had been greatly reduced at the end of 2004. Gou and Zheng measured the irrational bubbles in Chinese stock market from 2007 to 2014 based on the residual income value model, and qualitatively divided the bubbles according to the historical and actual situation [13]. They forecasted the irrational exuberance range of Chinese stock market in 2015, and gave a bubble warning to the bull market of Chinese stock market.

3 Description of Simulation Environment and Parameter

It is a closed frictionless capital market that has no tax or transaction cost. There are only two kinds of assets in the market: risky securities and cash, and investors can buy or sell securities at their own discretion according to their utility.

The total number of investors is N, which is divided into 10 grades of 0–9 according to their rational degree, of which Grade 10 is fully rational investors and Grade 0 is completely irrational investors. The rest of the Grade 1–8 investors are assumed to be more rational as the number increases.

The initial conditions of simulation: the initial assets of an assets of an investor are randomly assigned as $W_{i,0}$, $W_{i,0} \sim N(5000, 1000)$, that is, $W_{i,0}$ follows a normal distribution with a mean of 5,000 monetary units and a variance of 1,000; the initial ratio of risky securities to cash per investor is 1:1.

For simplicity, the price-driven consideration of risky securities is directly determined by the average position level of the market. The average position of the market is weighted by the amount of capital available to investors.

$$Average\ position\ of\ the\ market\ w_t = \sum(Market\ Value\ of\ Shares\ Held\ by\ Individual/Total\ Value\ of\ Assets\ Held\ by\ Individual) * (Total\ Value\ of\ Assets\ Held\ by\ Individual/Total\ Market\ Value\ of\ Assets) = Stock\ Market\ Value/Total\ Market\ Value\ of\ Assets$$

The price of a risky security is determined by the movements of $\bar{w}_t$, and the price of next period is determined by the price of the previous period.

The difference of investors' rationality lies in that the fully rational investors (Grade 9) can analyze the changes correctly and make correct forecast and take correct action on the price changes in the next period. And the irrational investor (Grade 0) is completely unaware of the change of $\bar{w}_t$, and the rationality of other Grade 1–8 investors are between these two. For the sake of simplicity, this paper assumes that the less rational the investor, the more likely he is to misjudge $\bar{w}_t$. For example, when $\bar{w}_t \approx 0$, he believes $\bar{w}_t = 1$; when $\bar{w}_t = 1$, he believes $\bar{w}_t \approx 0$, thus operating reversely and providing liquidity for the market.

Because the stock price is assumed to be driven by the average position of the market, the trading volume is not the key variable in the simulation research. It is simply assumed that at the market price, the lower volume is bought in the buyer's offer and the seller's offer.

This simulation is designed by using MATLAB simulation toolbox. If there is no special explanation, all simulation, chart and simulation data verification in this section are realized by MATLAB programming.

4 Simulation Results

The number of investors in the market is set to be 100, the parameter $h = n = 0.25$, the initial price of the securities is 4.6 currency units, and the simulation steps are 1,500. The series of simulation results are available.

4.1 Analysis of Price Chart

At 1500 steps, the simulated securities price trend is similar to the real market trend, securities prices have experienced band rises and falls, more in line with Elliott's wave theory in technical analysis. At about 600–800 steps, the market has experienced a consumptive increase, which explains that the investor position is heavy, Weakened financial incentives for risky securities prices, the price has consolidated and even fell; after step 800, a resistance decline has appeared, that is, the trend of "down—rebound—continue to fall"; after step 1000, the price has collapsed, this is the most lethal trend in the bear market (Figs. 1, 2 and 3).

In general, from the intuitive point of view, the simulation results are in line with the actual stock market price trend.

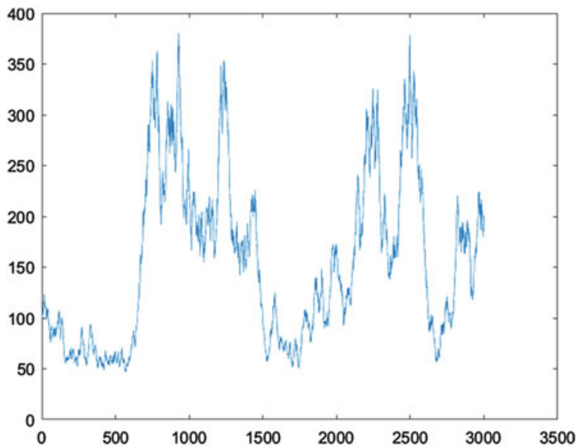

Fig. 1 Stock price trend chart (step length 3000)

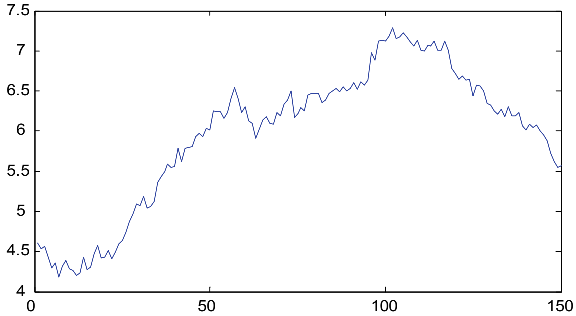

Fig. 2 Stock price trend chart (step length 150)

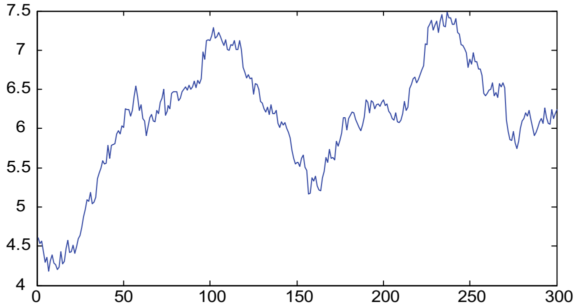

Fig. 3 Stock price trend chart (step length 300)

4.2 *Analysis of Price Yield (Taking Step Length of 1500 as an Example)*

For the simulation results above, the one step logarithmic rate of return can be calculated using a formula $r_t = \ln \frac{P_t}{P_{t-1}}$, as shown in Fig. 4:

Draw the histogram and compare it with the normal distribution as shown in Fig. 5:

From Fig. 5, we can see that the yield distribution of our security simulation price has a certain phenomenon of leptokurtosis and fat-tail. A further analysis, using skewness and kurtosis to test, is presented in Table 1.

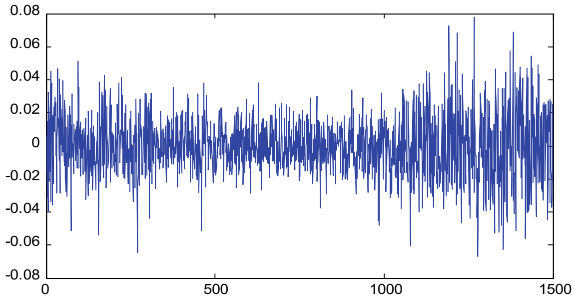

Fig. 4 Chart of single-step rate of return for securities

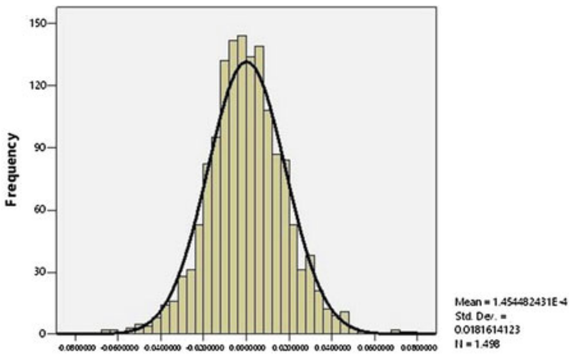

Fig. 5 Histogram of single-step rate of return for Securities

Table 1 Test on Kurtosis and Skewness of single-step rate of return for securities

N	Valid	1498
	Missing	0
Mean		.000145448
Skewness		.082
Std. error of Skewness		.063
Kurtosis		.916
Std. error of Kurtosis		.126

Skewness is a statistic that describes the symmetry of a variable's value distribution. Skewness of 0 indicates that the data distribution shape is the same as normal distribution skewness; a skewness greater than 0 indicates a larger positive deviation, either positively skewed or right skewed, with a long tail trailing to the right; a skewness lee than 0 indicates a large positively deviation, with negatively skewed or left skewed, with a long tail trailing. The bigger the absolute value of skewness is, the bigger the skewness of fractal is.

Kurtosis is a statistic that describes the degree of steepness and slowness of all values of a variable. If the kurtosis is 0, the data distribution has the same steepness and slowness as the normal distribution; a kurtosis greater than 0 indicates that the data distribution is steeper than the peak of normal distribution, which is a steep peak; a kurtosis less than 0 indicates that the data distribution is flatter than the peak of normal distribution, which is a flat peak. As can be seen from Fig. 3, the skewness is 0.082, and the kurtosis is 0.916, which are all obviously greater than 0. this shows that the distribution of returns of the securities is right-skewing, that is, tilting to the right, although it is not too steep. The test value of kurtosis is large, which shows that the peak phenomenon of yield is very obviously. The test result in Table 1 proves our intuitionistic conclusion from Fig. 5, that is, the simulation data shows that the return rate of security price presents the characteristic of leptokurtosis and fat-tail, and does not obey the hypothesis of normal distribution.

4.3 Analysis of Investors' Cumulative Yield (Taking Step Length of 1500 as an Example)

After the simulation with a step length of 1500, what is the return of the limited rational investor? This is one of our biggest concerns.

We set up a total of 100 investors in this simulation, so we can learn the total changes in assets from the beginning to the end after the simulation, and thus get its return ratio. The result shows that the ratio of lucrative investors to investors in loss is 22:78, which is in line with our intuition in reality: in a full bull-bear cycle, most investors lose money. If all investors within the yield of ±3% are accounted for as unprofitable, the analysis results are shown in Fig. 6:

Figure 6 vertically and horizontally shows the ratio of profit to loss, and Scale 1 shows the level of profit at 100%, meaning investors have doubled their principal. Scale −1 represents a 100% loss for investors. Of course, a loss of 100% is not easy, indicating that loss of investors incurs in security prices at any stage. Taking 3% as the boundary to calculate the profit and loss of investors, only 15% investors gain profit, 19% investors draw, remaining 66% investors lose in this simulation.

In addition, in terms of profit and loss, there are very few investors with large gain and losses. For example, there are only a few investors with losses close to 100%. Most of the rest are in the 20–50% loss range. While the profit-making investors are relatively few, the profit margin is striking. There are as many as seven investors who have nearly doubled or more than doubled, and the two investors who have made the highest profits that are seven times and more than six times, which shows that

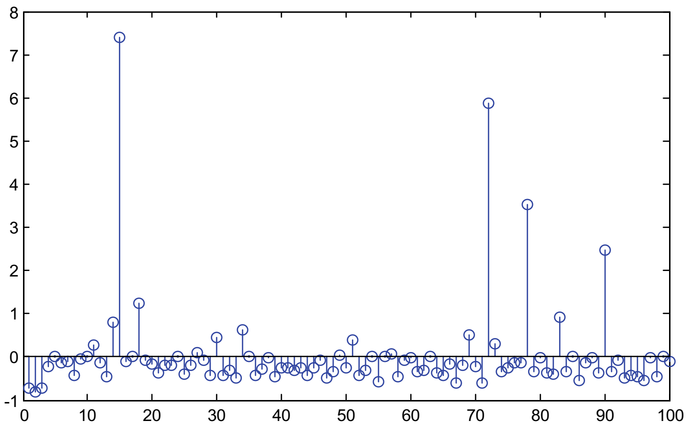

Fig. 6 Investor profit-loss ratio statement

Table 2 Rate of return

Rate of return	>3%	−3%–3%	<-3%
%	15	19	66

securities market is a zero-sum game market. Although most people lose money, but wealth will be concentrated to the profit of a few people, creating the "Gods" miracle in the market, such as Buffett, Sorrows and other dazzling stars of the capital market; on the other hand, although the investor's profit conclusion is quite clear in this simulation, but we cannot help but see, our simulation rule design is still relatively simple. For example, the rational investor is always rational, which ensures that those investors who end up making a profit, and that the profit margins are spectacular, are fixed.

5 Sensitivity Analysis of Simulation Results

Other things being equal, an increase in the number of investors in the market would reduce the volatility of security prices.

The simulation results of Fig. 7 show that when the number of investors is 40, the volatility of the market price is very large, and the fluctuation between high and low prices within 100 step length is more than 200%. As can be seen in Fig. 2, the market prices fluctuate by less than 75% over a period of 100 investors and 150 step length. Therefore, the increase of investors will reduce the volatility of prices, other things being equal in the market.

Other things being equal, the increase of step length helps to describe the complete price volatility cycle. This point is made intuitive by the comparison of Figs. 1, 2 and 3.

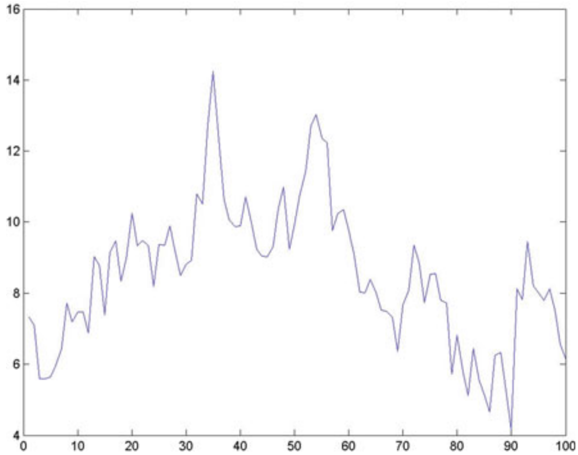

Fig. 7 Security price simulation with 40 investors (step length 100)

6 Comparison with the Results of the Empirical Study of the Shanghai Stock Index

The security simulation wield of the previous section is subject to the test of the leptokurtosis and fat-tail test, and this part is intended to be compare it with the actual market situation. This paper also takes the closing of the Shanghai Stock Index from May 6, 2008 to June 29, 2018 as an example to test its distribution with a total of 2472 days of data.

The statistical analysis software is SPSS11.5, and the data comes from the wind database.

6.1 Normal Probability Distribution Analysis of the Shanghai Stock Index (P-P Plots)

The normal probability distribution graph (P-P) is a kind of statistical graph to test the normal distribution, which is generated from the cumulative ratio of variable distribution and normal distribution. If the values of the variables are normally distributed, the normal probability distribution is plotted as a straight line specifying the upper-right corner from the zero of the vertical axis.

The inspection structure is shown in Figs. 8 and 9, as can be seen from the top half of Fig. 8, the distribution of the Shanghai Stock Index returns does not fall on the

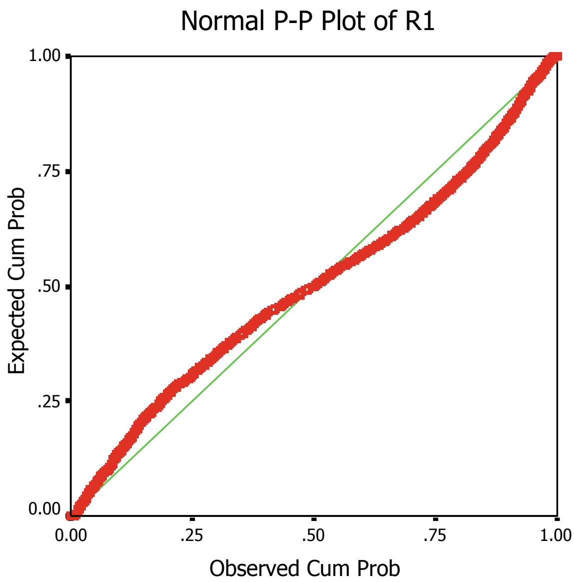

Fig. 8 The P-P plots of the shanghai stock index

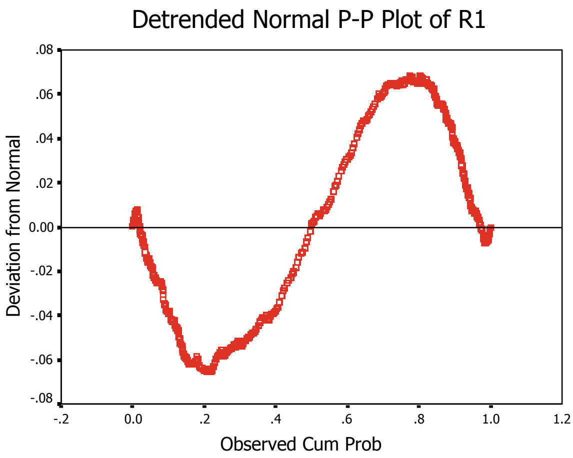

Fig. 9 The P-P plots of the shanghai stock index

diagonal, showing that the Shanghai Stock Index returns do not follow the normal distribution during the sample period.

The lower half of Figs. 8 and 9 is a discrete normal probability graph, which is judged by the following criteria: if the scattered points are uniformly distributed randomly around the line, they are normally distributed; if they are not random and have obvious curve patterns, they are non-normally distributed. Therefore, the test results show that the discrete normal probability graph of Shanghai Stock Index returns presents an obvious curve shape, which is non-normal distribution.

MODEL: MOD_1.
Distribution tested: Normal
Proportion estimation formula used: Blom's
Rank assigned to ties: Mean_
For variable R1 …
Normal distribution parameters estimated: location = .00050117 and scale = .01535803

6.2 Analysis of the Yield Distribution Chart of Shanghai Stock Index

Line graph is a kind of statistical graph which uses the rise and fall of line segments to show the change of phenomena. It is mainly used to show the change trend of phenomena in time, the distribution of phenomena and the dependence of phenomena.

Figure 9 shows a linear description of the daily return of the Shanghai Stock Index. As can be seen, the return is very volatile and shows a distinct clustering feature, that is, a large fluctuation is followed by a large fluctuation A small fluctuation is followed

Table 3 Kurtosis test table of Shanghai stock index yield

N	Valid	2471
	Missing	35
Kurtosis		5.644
Std. error of Kurtosis		.098

by a smaller fluctuation. Intuitively, we think that the Shanghai Stock Index has a high peak yield distribution and a thick tail, which can be considered as a distribution of leptokurtosis and fat-tail.

6.3 Skewness and Kurtosis Analysis

The concepts of skewness and kurtosis are described above. The test results for the Shanghai Stock Index are shown in Tables 2 and 3 (Fig. 10):

As can be seen from Table 2, the kurtosis of Shanghai Stock Index is 5.644, which is much greater than 0, showing excessive kurtosis and indicating that the daily return distribution is "leptokurtosis and fat-tail" as compared with the normal distribution; as can be seen from Table 3, the skewness of the Shanghai Stock Index is −0.104, less than 0, which indicates that the negative deviation is large and is negatively skewed or left skewed.

It can be seen that the above empirical results are almost the same as the simulation results in this paper. This, on other hand, validates the rationality of our simulation Table 4.

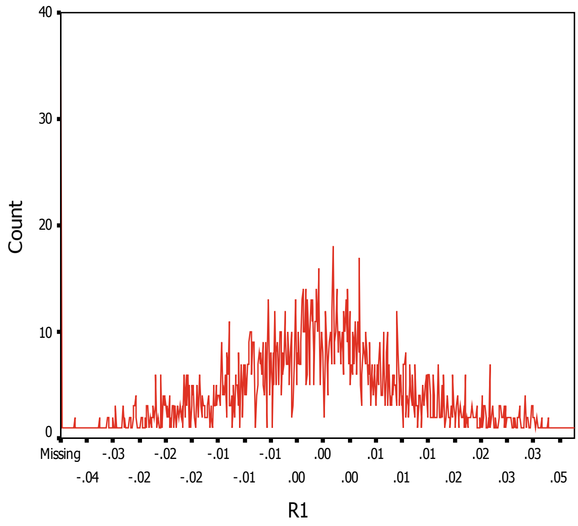

Fig. 10 Distribution scale of the Shanghai stock yield

Table 4 Skewness test table of Shanghai stock index yield

N	Valid	2471
	Missing	35
Skewness		−.104
Std. error of Skewness		.049

7 Conclusions

The artificial stock market established in this paper can simulate the actual situation of the market accurately, and can be used to simulate the process of stock price bubble, and the results are almost the same as the empirical study of the Shanghai Stock Index. The sensitivity analysis of the stock market shows that when the number of passive investors is small, or the number of emotional investors is large, the stock market bubble will easily occur and the stock price will deviate from its value. Of course, there is another kind of stock market crush when there are too few emotional investors and there is a liquidity crisis in the market, which should also be noted.

The existence of bubble economy has laid a hidden danger to the financial stability and national economic security. We must aim at the phenomenon of bubbles in the capital market, correctly analyze the reasons of the existence and formation mechanism of bubbles, and choose the corresponding solution to scientifically measure and evaluate bubbles, and prevent and control the expansion and bursting of bubbles, which can effectively regulate the problems existing in capital market and promote the healthy development of national economy. There are several specific solutions as follows:

Firstly, the regulatory authorities should pay attention to the psychology of investors and guide investors to invest rationally. At present, the main body of China's capital market is mainly individual investors. Because most individual investors lake professional knowledge and rich experience, they often play the role of noise traders in the capital market, and noise trading is one of the main causes of the bubbles in the capital market. Therefore, in order to control the noise trading bubble, the supervision department should strengthen the risk hint to individual investors, improve the professional quality of the market participants, establish the emotion supervision system, regulate the investors' behavior, and restrain the excessive speculation of investors.

Secondly, speed up the construction of the legal system and raise the level of supervision. It is necessary to perfect the legal environment of supervision, especially to establish a legal system to meet the requirement of market economy. Establish a sound multi-level regulatory system, and achieve the marketization of supervision activities. Establish the system of civil liability and compensation system of securities, and strengthen the protection of vulnerable groups.

Thirdly, reduce administrative intervention, and accelerate the circulation of non-tradable shares. First of all, the government should eliminate the institutional basis of administrative intervention, reconstruct the unified equity basis of the stock market, and convert non-tradable shares into common shares. In order to reduce the impact of non-tradable shares on the market, two strategic steps can be taken: the first step is to stop the increase of non-tradable shares, and the second is to eliminate the stock of non-tradable shares in one step.

Fourthly, strengthen information disclosure. The phenomenon of related party transactions, financial fraud and irregular financing behavior of listed companies frequently appears in the capital market. This kind of Information asymmetry phenomenon is one of the causes of the stock price bubble The supervision department needs to establish an effective information disclosure mechanism, supervise the financing scale and the use of funds of listed companies, perfect the laws and regulations of the capital market, so as to protect the interests of investors and prevent the stock market bubble.

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Interval-Valued AHP Method for Early Warning System Under Uncertainty

Lanting Yu and Menggang Li

Abstract As globalization progresses, the global economy becomes closely related and more difficult to predict. Early Warning System (EWS) is a major tool to monitor and forecast economic risk. In order to improve the timeliness of EWS, indicators obtained through big data analysis are increasingly utilized. However, the uncertainties about the extracted indicators are also augmented when the big data sources are not directly related to concerned economic problem. In this paper, our aim is to build an early warning systems (EWS) with multi-dimensional indicators, combined with genetic algorithm (GA) and analytic hierarchy process (AHP) to monitor the operation of the system in real-time. In order to handle the uncertainties, we use interval-valued variables and propose dominant criteria for different decision makers to meet their preferences.

Keywords Early warning systems · Genetic algorithm · Analytic hierarchy process · Interval analysis

1 Introduction and Literature Review

In recent years, with the development of economic globalization, the world's economics are getting inseparably associated. After a period of rapid growth of economic development, the instability of the complex and changeable economic market environment brings potential hazards and high uncertainty for the global economics. Economic crisis, financial crisis, currency crisis and other kind of crisis

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have caused great losses and negative impact on society. Risks have a gradual appearance and deterioration process, Early Warning Systems (EWS) contribute to prevent the economic crises in advance and can timely manage and control the emergencies.

The adoption of EWS have been widely discussed in different areas and different methods have been developed. Machine learning methods are evaluated in [1] using the European and American financial crisis database of 15 developed countries during the last 45 years. Comparing with model based methods, machine learning methods are overconfident in the prediction and may take wrong decisions. For currency crisis, researchers using fuzzy neural network algorithm to build a reliable causal relationship between variables, combining the learning ability of neural network with the reasoning mechanism of fuzzy logic, this hybrid model is more prescriptive and more efficient than neural networks and traditional regression models for early warning of currency crises [2]. In many developed and developing countries during the past two decades, people employing AHP to evaluate the performance of 48 commercial banks in Turkey from 1997 to 1999 with 26 financial criteria, and as the results, they concluded a banking performance score which may help the decision makers to select the banks to invest in [3]. For the performance of EWS for currency crises with real-time data, scholars using signal approach and discrete choice models (logit and probit models) to investigate three regions (Latin America, Central and Eastern Europe and Asia) [4], especially for the study of Brazil's currency crisis, as the future economic and trade cooperation between China and Brazil is very important, people should take full account of the impact of exchange rate on international trade and investment, so establishing EWS is an effective way to avoid futures currency crisis of China [5].

EWS is based on a series of economic indicators which may reflect the process of economic fluctuations in the most effective way. The first step in building an EWS is to construct a systematic frame of relevant indicators. For traditional macroeconomic analysis, researchers mainly use statistics provided by statistical departments, such as consumption indicators, financial indicators, investment indicators, et al. An EWS for economic and financial risks in Jamaica use 7 composite indicators that can be applied to identify and analyze vulnerabilities within key sectors with data over the period March 2001 to December 2015 [6]. In the work of analysis of EWS for Kazakhstan's economic and financial risks, they put forward a macro-prudential financial soundness analysis, for most developing and transformation countries with or without crisis experience before, or for the developed countries with limited data. Its target is to detect economic and financial sector weakness, design suitable policy to rescue the situation and undertake actions to prevent the vulnerabilities [7]. Recently, in order to improve the timeliness of the indicator, researches analyze the unstructured text data sources online related to the financial system and treat them as an important warning signal reflect the financial crisis before it occurs [8].

Realistic economic development is complex and changeable. It will be influenced by, for example, politic and diplomatic factors. Therefore, there exist inevitable uncertainties about the indicators mentioned above. In this paper our objective is to build an EWS which is able to forecast risks in the economic activities and handle the uncertainties about the economic uncertainties. We treat the aleatory uncertainty as the systematic risk which is irreducible and treat the epistemic uncertainty as the non-systematic risk which is reducible. In order to model the uncertainties, we consider using interval-valued variables. We build our EWS with the help of AHP method. In order to accelerate the decision of judgment matrix, Genetic Algorithm (GA) is adopted. The methodology of our system is introduced in Sects. 2 and 3. In Sect. 4 we will use a numerical example as a case study to demonstrate our methods, and the last part of Sect. 5 is conclusion.

2 Methodology

2.1 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was proposed by Saaty [9, 10] in 1970s, it is a method for formulating and analyzing decisions to solve multiple criteria decision problems by setting their priorities [11], and it has been implemented extensively all over the world. The basic idea of AHP method is to divide the hierarchical characteristics of the system from high to low into several levels, and establish a pyramidal tree hierarchy to describe the inter-relationships between elements. Instead of prescribing a correct decision, AHP method decomposes problem into different levels (i.e. three hierarchies: goal, criteria, alternative), and helps decision makers find one alternative which is best suited to their goal and satisfy their understanding of the problem. According to the judgment of certain reality, the importance of each element in each hierarchy is quantitatively expressed by comparing with other element in the same hierarchy. Using mathematical methods to determine the weight of each element in order to express the relative importance order of all elements at each hierarchy.

AHP method provides a general and reasonable framework for constructing a decision problem, which contributes to represent and quantify its elements, and connects them to overall goals to give valuable solutions. Users of the AHP method usually decompose their problem into hierarchies of sub-problems which can be analyzed independently and become much easier to comprehend. The elements of the hierarchy may relate to many factors of decision problem: tangible or intangible, roughly estimated or carefully measured, poorly or well understood applied to the decision. As soon as the hierarchy is built, decision maker systematically evaluates its divers elements by comparing them pair-wisely, with respect to their effect on an element above them in the hierarchy.

The essence of AHP method is based on expert's judgments or experiences from historical data, and evaluates weights by pair-wise comparison. It transforms these evaluations into numerical values which can be dealt and compared over the entire range of the problem. A numerical weight is derived for each element of the hierarchy, allowing various and often incomparable elements to be compared with one another in a rational and stable way. The AHP method has the capability to be distinguished from other decision making techniques. In the final step of the process, numerical priorities about weights are calculated for each of the decision alternatives. These values stand for the alternatives' relative ability to reach the decision goal, so the straightforward consideration of the various courses of action are approved.

The main steps of AHP methods are: establish the hierarchies; build the judgment matrix; measure the weight of each elements; make consistency check; calculate and sort the relative importance of each indicator. Each element of the judgment matrix is selected from 1–9 scale (as shown in Table 1 below) proposed by Saaty [12–14], it is frequently used to represent the pair-wise comparison result of two elements.

And a_{ij} expresses the element of the *i*-th row and *j*-th column in the judgment matrix *A*, $A = (a_{ij})_{n \times n}$, where $a_{ij} > 0$, $a_{ij} = 1/a_{ji}$, and $a_{ii} = 1$.

As the variables we considered are interval-valued type of data, the traditional 1–9 scale of importance degree is no more suitable, we proposed a new scale (see Table 2 below) where the comparison result of two elements is not an exact value, but imprecise value expressed in interval.

Table 1 1–9 scale of importance degree

The degree of importance	Definition
1	Element *a* and element *b* with same importance
3	Element *a* is slightly important than element *b*
5	Element *a* is important than element *b*
7	Element *a* is much important than element *b*
9	Element *a* is extremely important than element *b*
2, 4, 6, 8	The importance degree between the above adjacent judgments

Table 2 Interval scale of importance degree

The degree of importance	Definition
1.0	Element *a* and element *b* with same importance
[2.0, 3.0]	Element *a* is slightly important than element *b*
[4.0, 5.0]	Element *a* is important than element *b*
[6.0, 7.0]	Element *a* is much important than element *b*
[8.5, 9.9]	Element *a* is extremely important than element *b*
[1.0, 2.0]; [3.0, 4.0]; [5.0, 6.0]; [7.0, 8.5]	The importance degree between the above adjacent judgments

The main problem of AHP method is the consistency of the judgment matrix. In this paper, the consistency of the judgment matrix is attributed to the optimization problem of nonlinear system. We use AHP method based on genetic algorithm to evaluate the EWS with high degree of automation and consistency.

2.2 Genetic Algorithm (GA)

Genetic algorithm is a method by simulating the natural evolution process to obtain the optimal solution, it is a kind of evolutionary algorithm, and was proposed by Holland in 1975 [15].

Genetic algorithm is an algorithm which based on the natural selection of the global random search, it can randomly search the entire space to carry out effective evaluation based on certain strategies, and continuously using some genetic operators to keep the problem changing until find the optimal solution.

The GA method and penalty function technique penalize the objective function corresponding to the infeasible solution to transform the constrained optimization problem to an unconstrained optimization problem. The genetic algorithm optimization method belongs to the family of heuristic optimization techniques, other of them are simulated annealing, Tabu search and evolutionary strategies. GAs have been displayed and testified to the optimal solution for many various tough problems. The efficiency of finding good solutions of GA is an ability which depends on properly customizing the encoding, breeding operators (selection, crossover and mutation) and fitness measures to the specific engineering problem.

The basic idea of GA is based on Darwin's evolution theory and Mendel's genetic theory, which embodies the principle of survival of the fittest in the nature. It is an algorithm for simulation biological evolution, for a population composed by a group of individuals, each individual is evaluated for merits and demerits, several individuals go through some random changes to inherit and produce new offspring, two main random changes are crossover and mutation, after several generations, the population may turn into an optimal situation which its individuals have the best adaptability to the environment.

Solving the early-warning problems with uncertain data is a challenging task, this paper describes AHP method based on the use of genetic algorithm and interval comparison criteria to determine solutions of EWS.

2.3 Decision Making Under Uncertainty

As the existence of uncertainty, we concentrate on approaches for decision making under interval-valued probabilities. And as AHP is a widely used method which make full use of people's knowledge and experience to quantify many qualitative influencing factors, so decision maker's personnel subjective judgment may plays determinative role, and in the process of GA method, we need to choose the excellent genes to inherit offspring, so with the existence of uncertainty, we also need some criteria to facilitate the selection process.

Note that decision making is a far less impersonal matter, which means it is a process of determining the most optimal actions or alternatives than others. But decision is also a more personal matter, which means that different decisions may have different consequences, an action that is optimal for this situation may not necessarily also optimal for another situation. The problem of uncertainty treatment and the problem of decision making are closely related, because it is useful to study practical problems which combined the two problems together. For instance, in one situation, the background information or knowledge is insufficient, people need to make a decision and select an action because people always prefer to get the optimal result.

In real life decision problems, the indeterminate situations always exist, ordering provides a very natural and effective way which helps to solve them. But how to handle the different ranking relationships is always an essential research problem. In general, an order or a rank is a sequence of elements according to some defined criteria or natural relationships, such as numerical order of values, alphabetical order of letters, or power set order between subsets whose ranking relation is the inclusion-exclusion relation. Thus several different approaches can be taken to making decisions under uncertainty. Here list them in two types: complete order ranking rules and partial order ranking rules [16, 17].

- Complete order ranking rules:
  (1) *Maxmin criterion*: an interval $x \in \left[\underline{x}, \bar{x}\right]$ is said to be better than interval $y \in \left[\underline{y}, \bar{y}\right]$ according to the maximin criterion, denoted $x \succ_{Mm} y$, if $\underline{x} > \underline{y}$.
  (2) *Maxmax criterion*: an interval $x \in \left[\underline{x}, \bar{x}\right]$ is said to be better than interval $y \in \left[\underline{y}, \bar{y}\right]$ according to the maximax criterion, denoted $x \succ_{MM} y$, if $\underline{x} > \bar{y}$.
  (3) *γ-Hurwicz criterion*: an interval $\mathrm{x} \in \left[\underline{\mathrm{x}}, \bar{\mathrm{x}}\right]$ is said to be better than interval $\mathrm{y} \in \left[\underline{\mathrm{y}}, \bar{\mathrm{y}}\right]$ according to the γ-Hurwicz criterion, denoted $x \succ_{H(\gamma)} y$, if $\gamma\underline{x} + (1-\gamma)\bar{x} > \gamma\underline{y} + (1-\gamma)\bar{y}$, where $0 < \gamma < 1$.
- Partial order ranking rules:
  (1) *Interval dominance criterion*: an interval $x \in \left[\underline{x}, \bar{x}\right]$ is said to be better than interval $y \in \left[\underline{y}, \bar{y}\right]$ according to the interval dominance criterion, denoted $x \succ_{ID} y$, if $\underline{x} > \bar{y}$.
  (2) *Difference comparison criterion*: an interval $x \in \left[\underline{x}, \bar{x}\right]$ is said to be better than interval $y \in \left[\underline{y}, \bar{y}\right]$ according to the difference comparison criterion, denoted $x \succ_{DC} y$, if $\underline{x-y} := inf(x-y) > 0$.

(3) *Interval bounds criterion*: an interval $x \in [\underline{x}, \bar{x}]$ is said to be better than interval $y \in [\underline{y}, \bar{y}]$ according to the interval bounds criterion, denoted $x \succ_{IB} y$, if $\underline{x} > \underline{y}$ and $\bar{x} > \bar{y}$.

Once the decision situation has been organized, as these order criteria reflect the diverse degrees of different decision-maker's conservatism or liberalism of how they arrive at a decision, the intervals with overlap can be compared with these criteria.

3 Encoding Scheme

(1) The comparison result of two elements' importance is determined by the decision maker and is expressed in interval-valued form, i.e. the importance degree is not expressed in a concrete determined value but in a range of interval values which corresponding to the interval scale, where the specific range of interval values are determined by the genetic algorithm. The elements of interval-valued data in the judgment matrix are expressed in binary strings form as chromosomes.
(2) Initialization. Producing the initial group, which represents a set which satisfying the judgment matrix, randomly generated binary strings which represent a set of parameter values that form the first generation group.
(3) Calculate Fitness.
(4) Selection. According to the survival of the fittest principle proposed by Darwin, from the existing group of new individuals, the greater the degree of adaptability, the greater the probability that the individual will be chosen, the more the individual meet the consistency requirements of the judgment matrix.
(5) Crossover, mutation operation. Randomly select chromosomes in the group for pairing, and according to a certain crossover probability to exchange genes to produce new individuals; according to a certain mutation probability to produce new individuals, the aim of crossover is to make each solution have the opportunity to exchange its excellent genes, the aim of mutation is to have a global optimal solution.
(6) Repeat the above process until the optimization criterion is met, then decode the maximum fitness value to obtain the corresponding judgment matrix.

The weight values obtained by genetic algorithm represent importance degree of the elements in lower hierarchy comparing with one element of the upper hierarchy. Our final purpose is to obtain the total sort weight of all elements in each hierarchy to the target hierarchy.

4 Case Study

Combine the systematic analysis with the fiscal risk matrix proposed by Brixi [18], the formation mechanism of China's fiscal risk are decomposed into four parts: Macro-economy operational risk factor (X_1), fiscal system risk factor (X_2), fiscal debt risk factor (X_3), and fiscal revenue and expenditure risk factor (X_4). Each part contains several sub-risk factors, expressed as X_{ij}, where X_1 contains 5 sub-risk factors, X_2 contains 3 sub-risk factors, X_3 contains 6 sub-risk factors, and X_4 contains 4 sub-risk factors. e.g. X_{23} means the third sub-risk factor of the fiscal system risk factor. According to their relations of each risk factor in different hierarchy, we build the judgment matrix of the four parts in Table 3.

And the judgment matrices of each fiscal risk factor composed by their sub-risk factors are expressed in the following tables (Tables 4, 5, 6 and 7).

The synthetical fiscal risk function can be expressed in (1):

$$R = \sum\nolimits_{i=1}^{n} (R_i \times P_i) \tag{1}$$

Table 3 Judgment matrix of four fiscal risk factors

Fiscal risk factors	X_1	X_2	X_3	X_4
X_1	1	$\left[\frac{1}{1.2}, \frac{1}{0.9}\right]$	$\left[\frac{1}{3.6}, \frac{1}{3.1}\right]$	$\left[\frac{1}{4.3}, \frac{1}{3.7}\right]$
X_2	[0.9, 1.2]	1	$\left[\frac{1}{2.3}, \frac{1}{1.4}\right]$	$\left[\frac{1}{3.3}, \frac{1}{2.8}\right]$
X_3	[3.1, 3.6]	[1.4, 2.3]	1	$\left[\frac{1}{2.1}, \frac{1}{1.5}\right]$
X_4	[3.7, 4.3]	[2.8, 3.3]	[1.5, 2.1]	1

Table 4 Judgment matrix of macro-economy operational risk factor

X_1	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
X_{11}	1	[1.6, 2.5]	[1.1, 1.7]	[1.9, 2.7]	[0.8, 1.3]
X_{12}	$\left[\frac{1}{2.5}, \frac{1}{1.6}\right]$	1	$\left[\frac{1}{2.2}, \frac{1}{2.6}\right]$	[0.7, 1.1]	$\left[\frac{1}{2.2}, \frac{1}{1.8}\right]$
X_{13}	$\left[\frac{1}{1.7}, \frac{1}{1.1}\right]$	[2.2, 2.6]	1	[2.1, 2.5]	[0.7, 1.1]
X_{14}	$\left[\frac{1}{2.7}, \frac{1}{1.9}\right]$	$\left[\frac{1}{1.1}, \frac{1}{0.7}\right]$	$\left[\frac{1}{2.5}, \frac{1}{2.1}\right]$	1	$\left[\frac{1}{2.5}, \frac{1}{1.5}\right]$
X_{15}	$\left[\frac{1}{1.3}, \frac{1}{0.8}\right]$	[1.8, 2.2]	$\left[\frac{1}{1.1}, \frac{1}{0.7}\right]$	[1.5, 2.5]	1

Table 5 Judgment matrix of fiscal system risk factor

X_2	X_{21}	X_{22}	X_{23}
X_{21}	1	[0.8, 1.6]	[1.9, 2.4]
X_{22}	$\left[\frac{1}{1.6}, \frac{1}{0.8}\right]$	1	[1.7, 2.6]
X_{23}	$\left[\frac{1}{2.4}, \frac{1}{1.9}\right]$	$\left[\frac{1}{2.6}, \frac{1}{1.7}\right]$	1

where R is the overall fiscal risk value, R_i is the i-th fiscal risk factor's risk value, P_i is the i-th fiscal risk factor's weight correspondingly.

And

$$R_i = \sum_{j=1}^{m} \left(R_{ij} \times P_{ij}\right) \tag{2}$$

where R_{ij} is the j-th sub-fiscal risk factor's risk value of the i-th fiscal risk factor, P_{ij} is the j-th sub-fiscal risk factor's weight correspondingly.

The fiscal risk status are classified into four regions, see the Table 8 below.

Combined (1) with the data from economic statistic database of these years, and using GA method, we obtained that China's fiscal risk status is basically safe.

Table 6 Judgment matrix of fiscal debt risk factor

X_3	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}	X_{36}
X_{31}	1	[1.7, 2.4]	[3.2, 3.6]	[1.9, 2.5]	[1.5, 2.2]	[2.1, 2.4]
X_{32}	$[\frac{1}{2.4}, \frac{1}{1.7}]$	1	[1.6, 2.3]	[0.7, 1.2]	[0.8, 1.5]	[0.9, 1.3]
X_{33}	$[\frac{1}{3.6}, \frac{1}{3.2}]$	$[\frac{1}{2.3}, \frac{1}{1.6}]$	1	$[\frac{1}{2.2}, \frac{1}{1.8}]$	$[\frac{1}{2.4}, \frac{1}{1.9}]$	$[\frac{1}{2.5}, \frac{1}{1.7}]$
X_{34}	$[\frac{1}{2.5}, \frac{1}{1.9}]$	$[\frac{1}{1.2}, \frac{1}{0.7}]$	[1.8, 2.2]	1	[0.7, 1.4]	[0.9, 1.2]
X_{35}	$[\frac{1}{2.2}, \frac{1}{1.5}]$	$[\frac{1}{1.5}, \frac{1}{0.8}]$	[1.9, 2.4]	$[\frac{1}{1.4}, \frac{1}{0.7}]$	1	[0.8, 1.2]
X_{36}	$[\frac{1}{2.4}, \frac{1}{2.1}]$	$[\frac{1}{1.3}, \frac{1}{0.9}]$	[1.7, 2.5]	$[\frac{1}{1.2}, \frac{1}{0.9}]$	$[\frac{1}{1.2}, \frac{1}{0.8}]$	1

Table 7 Judgment matrix of fiscal revenue and expenditure risk factor

X_4	X_{41}	X_{42}	X_{43}	X_{44}
X_{41}	1	$[\frac{1}{2.2}, \frac{1}{1.7}]$	$[\frac{1}{2.4}, \frac{1}{1.9}]$	$[\frac{1}{4.3}, \frac{1}{3.7}]$
X_{42}	[1.7, 2.2]	1	[0.8, 1.2]	$[\frac{1}{2.3}, \frac{1}{1.8}]$
X_{43}	[1.9, 2.4]	$[\frac{1}{1.2}, \frac{1}{0.8}]$	1	$[\frac{1}{2.4}, \frac{1}{1.7}]$
X_{44}	[3.7, 4.3]	[1.8, 2.3]	[1.7, 2.4]	1

Table 8 Classification of fiscal risk status

Value of risk assessment	0–25	25–50	50–75	75–100
Fiscal risk status	Safe	Basically safe	Risky	Significantly risky

5 Conclusion

In this article, we build an EWS with multi-dimensional indicators. AHP method is utilized to forecast potential risks. Considering the uncertainties exists in the indicators obtained through statistical methods or machine learning, we model the uncertainty with interval-valued variable and propose dominant criteria for interval comparison. In order to accelerate the decision of the judgment matrix, genetic algorithm is used to perform an effective sampling on the parameter space. The proposed method is examined by applying on a fiscal risk warning problem.

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The Influence of Product Architecture and Supply Chain Concentration on Supply Chain Performance

Caili Duan, Xiaochun Chen, and Yuanxun Gu

Abstract Supply chain is an important support for value creation, and product is the carrier for realizing the value. The coordination between product architecture design and supply chain management is the premise for enterprises to cope with rapid changes and meet the market demands. The view that product architecture and supply chain interact with each other has been confirmed by many scholars, but the influence mechanism between the two is still unclear. We collected data from 221 companies and drew the following conclusions through analysis. (1) product architecture has a significant impact on supply chain performance. The modularity of product architecture, the degree of standardization of interface, and the reuse of components have a significant positive impact on supply chain performance. (2) supply chain centralization can enhance the effect of product architecture on supply chain performance. When supply chain concentration is high, product architecture is easier to play its advantages, thereby improving supply chain performance.

Keywords Product architecture · Supply chain performance · Supply chain concentration

1 Introduction

With the rapid development of technology, products are in a fast cycle market, if an enterprise wants to obtain the competitive advantage, it needs not only higher product development capacity and production capacity, but also a fast and sensitive

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supply chain. Supply chain is an important support for value creation and value realization. Integrating product architecture design and supply chain decision- making in product development is the key to value realization. However, current research on product design and supply chain design remains in their respective fields. The decoupling of product architecture improves the flexibility of product architecture. Product architecture design is the coordination mechanism for production, process and supply chain matching. Therefore, the interaction between product architecture and supply chain has gradually attracted the attention of scholars. Summarizing the current research on the relationship between product architecture and supply chain, most scholars explained the matching relationship between product architecture and supply chain through theoretical deduction and mathematical modeling, and very few empirical studies have been conducted. Therefore, based on the existing research, this paper analyses the relationship between product architecture and supply chain performance of manufacturing enterprises, and draws the conclusion that the product architecture affects supply chain performance. The impact mechanism provides a theoretical reference for product architecture design and supply chain management.

2 Conceptual Framework and Research Hypothesis

2.1 Supply Chain

Forrester first proposed the concept of supply chain [1], then scholars defined the concept of supply chain as an enterprise network which is made of many independently economic entities that are related to each other and work together to carry out value-added activities and dynamically configure resources. Since then, the research on supply chain management has gradually received attention. The concept of supply chain management was first proposed by Houliban in the 1980s [2]. With the deepening of scholars' research on supply chain management, the scope of supply chain management has been expanded. Cooper et al. argued that supply chain management emphasizes the transaction and cooperation among the node enterprises of supply chain [3]. Cooperating with each other improves the efficiency of supply chain which is an innovation management strategy among enterprises. Domestic scholars such as Ma tend to integrate the concept of management, he said that supply chain management implements the logistics planning and control functions in the whole process of supply chain from the initial supplier to the final consumer [4]. From the above, this paper arguments that supply chain management is a comprehensive management process in which enterprises plan, coordinate and integrate supply chain information flow, logistics and capital flow scientifically in order to respond quickly to the market.

Supply chain performance is the overall efficiency of supply chain operation, including the internal performance of the enterprise itself and the coordination and cooperation performance among the node enterprises [5]. In the existing literature, most of the research focused on the establishment of supply chain performance evaluation and index system. In recent years, scholars have found that many factors can affect supply chain performance, such as upstream and downstream partnerships in supply chains [6]. Many experts have devoted themselves to the study of new methods for evaluating supply chain performance, such as increasing order fulfillment efficiency from OFE model to SCOR model to reflect the comprehensive correlation between input and output; others have used structural equation model to analyze the relative weights of each evaluation index, identify the main factors affecting supply chain performance and summarize the sustainability. Using factor analysis method to simplify the indicators, the evaluation strategy of supply chain performance establishes a scientific and reasonable standardized evaluation index system [7]. Xiong believed that improving the participation level of suppliers is conducive to improving the operation performance of the supply chain, while increasing the participation level of customers is conducive to improving the service performance of the supply chain [8]. Liu et al. after studied the profit sharing contract in supply chain thought that profit sharing contract has an impact on supply chain performance [9]. Taking conflict management ability and cooperation stability as influencing factors, Zhou studied their influences on supply chain and concluded that both of them are beneficial to improve supply chain performance [10]. By analyzing relevant researches on supply chain performance and combining the purpose of this paper, the supply chain performance measurement scale developed by Lu and Li was adopted to measure the supply chain performance. The scale includes three dimensions: financial performance, production service performance and supplier operation performance, which includes 12 items in total [11].

In order to explore the influence of supplier relationship on the relationship between product architecture and supply chain performance, this paper chooses supply chain concentration as the moderating variable. The concentration of supply chain is composed of the concentration of suppliers upstream and downstream of the supply chain and customer concentration. Zhuang also pointed out that supply chain concentration consists of two dimensions: supplier concentration and customer concentration [12]. This model is conducive to long-term cooperation between enterprises and suppliers. Customer concentration reflects the concentration of customers, the higher the customer concentration, the fewer the number of customers [13]. Wu regarded supply chain concentration as the integration of supply chain management [14]. Other scholars have different definitions of supply chain concentration, in essence, supply chain concentration reflects the idea of integration of supply chain resources and management optimization. Therefore, this paper argues that the essence of supply chain concentration is the strengthening of strategic partnership among supply chain enterprise members and the enhancement of information sharing and process management capabilities. On this basis, this paper defines the concentration of supply chain as the close partnership among the enterprises, the upstream and downstream suppliers and customers. This paper chooses three indicators to measure the concentration of supply chain: the concentration of enterprises and upstream suppliers, which is measured by the sum of procurement ratios of the top five suppliers, and the concentration of enterprises and downstream customers, which is measured by the sum of sales ratios of the top five customers.

2.2 Research on Product Architecture

The term architecture comes from the discipline of systems management to simplify complex system problems. The earliest application of architecture to management was in Ulrich' research [15], who proposed the concept of product architecture and applied architecture-related theory to product development and design. Moreover, he believed that product architecture is a systemic solution that is achieved by assigning different functions of the product to different physical modules [16], embodying the decomposition and integration of product systems. Based on product characteristics, Fixson believed that the product architecture includes the type and number of modules and interfaces between two modules, which reflect the basic structure of the product [17]. And modules do not exist independently, but interact and influence, and then react and express through the interfaces [18]. Therefore, the product architecture embodies the system integrity of the product, and the interface, module and system are the three basic elements of the product architecture. The emergence of modular product architecture provides a solution for complex product design, it also reduces the difficulty of supply chain management and operation management related to complex product design, therefore it attracts the attention of academic circles.

When Baldwin and Clark studied the role of modularity, they proposed six operations to change product architecture, namely, splitting, substituting, adding, removing, creating new design rules, transplanting, and briefly described the relationship between product architecture changes and organizational changes [19]. Christensen indicated that modular architecture and integrated architecture are two extremes in spectrum. When enterprises rely on functions to gain competitive advantage, they will choose integrated architecture and modular competitive advantage when enterprises gain competitive advantage with speed [20]. Whether a product is modular or integrated can only be judged when compared with other products, so it is only a relative attribute of product architecture. It can be seen that the evolution of product architecture is not a simple choice between modularity or integration, but needs to be adjusted according to the context [21]. In this paper, Fujimoto and Takahiro's views were adopted to measure the form of the product architecture through the modularity, the degree of interface standardization and the reuse of components. The larger the value of the three dimensions, the more integrated the form of the product architecture would be.

2.3 Research Hypothesis and Model Construction

With the deepening of scholars' research on supply chain and product architecture, many scholars have studied the influence of product architecture on supply chain management and design. Yassine et al. believed that the modular product architecture can reduce the interaction between components and the coordination difficulty of the R&D team, ultimately reducing the R&D cost and shortening the lead time of delivery, which is conducive to improving the response capacity and efficiency of the supply chain [22]. At the same time, modularized norms and uniform language can reduce the effort of suppliers and customers, which can promote the exchange of information between the two parties, and help to improve the level of trust between the two sides, thereby reducing risk of cooperation between companies and suppliers and customers [23]. In addition, component reuse in modular products helps to reduce the investment risk of module or component manufacturers, and enables manufacturers to diversify their products at the lowest cost, thus quickly meeting different market needs. Therefore, modular product architecture enables enterprises to achieve parallel production, thereby improving the resource utilization of enterprises and shortening the lead time of product delivery. However, some scholars argued that modularization of product architecture will increase the cost of assembly and transportation, and that when an enterprise outsources modules, it will lose the knowledge of architecture and technical information related to modules in the long run.

In summary, product architecture is closely related to supply chain performance, but there is no consistent conclusion on the research of product architecture on supply chain performance, and scholars mostly use case studies and theoretical deduction to explain the relationship between product architecture and supply chain. Therefore, this paper proposes the hypothesis:

H1: The product architecture form has a significant impact on supply performance.

H1a: The modularity of product architecture has a positive impact on supply chain performance.
H1b: Component reuse has a positive impact on supply chain performance.
H1c: The standardization of interface has a positive impact on supply chain performance.

Based on transaction cost theory and resource-based theory, supply chain partners can reduce transaction costs and save transaction time through cooperative trust, thus improving the performance of core enterprises and even the whole supply chain. High-quality cooperation between enterprises and suppliers can make supply chain more competitive [24]. The high concentration of the supply chain is conducive to the good cooperation between the company and the procession, and the long-term cooperation has established a good trust among the industry, suppliers and customers, and formed a transaction specification. When Nuria et al. studied the supply chain cooperation relationship they concluded that the operational efficiency of decentralized partner enterprises lacking contract mechanism in the supply chain was difficult to improve [25]. Jiang studied the characteristics of partnership, and believed that relationship trust and institutional trust positively affect the operation performance and financial performance of supply chain [26]. Long put forward that commitment mechanism helps manufacturers to maximize benefits in multiple supplier proposals [27]. Guo et al. constructed a coordination model of competition and cooperation game of three-level supply chain [28]. It was found that with the increase of the number of suppliers and sellers, the competition between suppliers and sellers became increasingly fierce, the bargaining power of suppliers and sellers would weaken, and the bargaining position of core enterprises would rise, thus improving the supply chain performance of core enterprises. However, Behncke and others show that the higher the modularity of product architecture, the higher the demand for the relationship between supply chains [29]. Therefore, the role of product architecture is affected by the cooperation among enterprises, suppliers and customers. However, the cooperation relationship of supply chains varies greatly with the concentration of supply chains, so the impact of product architecture on supply chain performance is significant. It will be disturbed by supply chain concentration. Thus, the following assumptions are put forward:

H2: Supply chain concentration has a significant impact on supply performance.

H2a: Supplier concentration has a positive impact on supply chain performance.
H2b: Customer concentration has a positive impact on supply chain performance.

H3: Supply chain concentration plays a moderating role in the impact of product architecture on supply chain performance.

H3a: Supply chain concentration plays a moderating role in the relationship between modularity and supply chain performance.
H3b: Supply chain concentration plays a moderating role in the relationship between interface standardization and supply chain performance.
H3c: Supply chain concentration plays a moderating role in the relationship between component reuse and supply chain performance.

The theoretical model of the article is shown in Fig. 1.
The regression equation is

$$Y = \beta_0 + \beta_1 X + \beta_2 m + \varepsilon \tag{1}$$

$$Y = \beta_0 + \beta_1 X + \beta_2 m + \beta_3 X m + \varepsilon \tag{2}$$

The partial derivative of Y with respect to m is obtained:

$$\frac{\partial \hat{y}}{\partial x_1} = \beta_1 + \beta_3 x_2 \tag{3}$$

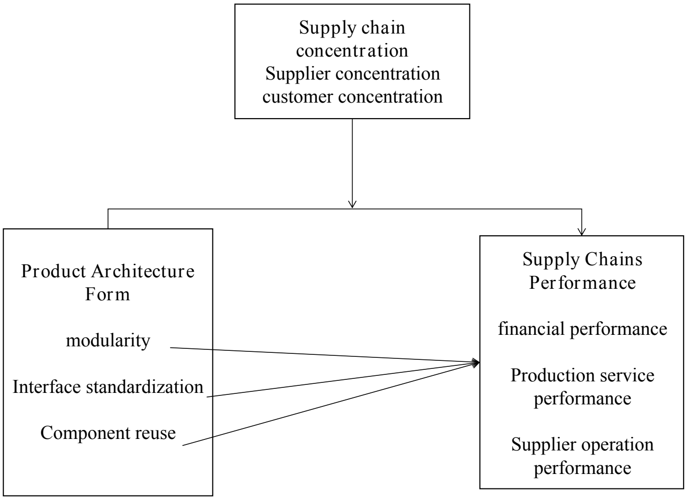

Fig. 1 Hypothesis model

If β_3 is significant, then the adjustment variable is significant.

3 Research Design

We adopt the method of questionnaire survey and use SPSS19.0 statistical software to analysis the data. Before conducting the formal questionnaire survey, we first test the reliability and validity of the scale, and collect the data on the basis of ensuring the reliability and validity of the scale.

3.1 Data Collection

The research focused on manufacturing enterprises in North China. In August 2018, pre-study was carried out, and 40 questionnaires were collected. According to the survey results, the measurement of each variable has good reliability and validity. On September 20, 2018, a formal data survey was conducted, and 260 manufacturers were surveyed and 221 questionnaires were returned. The validity rate of the questionnaire was 81%.

Table 1 The results of confirmatory factor analysis

Variable	Fitting index					
	χ^2/df	CFI	GFI	PNFI	RMSEA	AGFI
PAF	1.934	0.857	0.878	0.570	0.045	0.850
SCP	2.020	0.800	0.850	0.789	0.039	0.824
SCC	2.568	0.936	0.946	0.678	0.056	0.868

3.2 Construct and Measurement

The reliability of the results is tested by the Cronbach's coefficient.

$$\alpha = \frac{\kappa}{\kappa - 1}(1 - \sum \frac{s_i^2}{s_t^2}) \quad (4)$$

α is the reliability coefficient, κ is the number of questions tested, s_{i}^2 is variance of scores for each question, s_{t}^2 is variance of total score.

The Cronbach's coefficient of product structure form is 0.879, and the Cronbach's coefficient of supply chain performance is 0.912. The Cronbach's coefficient of supply chain concentration is 0.935. The Cronbach's coefficient of the scale used in this paper is greater than 0.80, so the scale has good reliability and can be further analyzed.

To test the validity of the scale, χ^2/df, RMSEA, GFI, CFI, AGFI and PNFI are used to observe the structural validity of the scale.

$$\frac{x^2}{df} = \frac{(N-1)F}{df} \quad (5)$$

If χ^2/df < 3, then the results are valid. The results of the test are shown in the table. All the indicators in the validity test result of the scale reach the acceptable range, so the scale used in the study has good structural validity (Table 1).

3.3 Data Analysis and Results

The mean, standard deviation and correlation coefficient of each variable are as follows. Table 2 shows that the correlation coefficient between variables is significant. The correlation coefficient formula is

Table 2 Mean, standard deviation and correlation matrix of variables

Variable	1	2	3	4	5	6	7
Business scale							
Industry type	−0.017						
Sales	0.054	0.035					
Years	0.133*	−0.264	0.273				
PAF	−0.194	0.006	0.037	−0.123			
SCP	0.029*	0.136	0.253**	0.345	0.468**		
SCC	0.183**	0.022	−0.410	0.129	0.473**	0.480**	
Mean value	3.580	3.770	2.970	3.400	4.117	3.834	3.947
Standard deviation	0.495	0.886	0.380	0.390	0.863	1.026	0.804

$$r = \frac{\sum_{i=1}^{n} (x_1 - \overline{x})(y_1 - \overline{y})}{\sqrt{\sum_{i=1}^{n} (x_1 - \overline{x})^2 \sum_{i=1}^{n} (y_1 - \overline{y})^2}} Z \tag{6}$$

3.4 Hypothesis Test

The relationship between variables and the regulatory effect of regulatory variables are tested, and the results are shown in the Table 3.

In the Table 3, R represents goodness of fit. It is used to measure the goodness of fit of the estimated model to the observed values. The closer its value is to 1, the better the model will be. Adjusted R^2 represents the ratio of the sum of squares of regression to the sum of squares of total dispersion.

$$\text{Adjusted } R^2 = 1 - \frac{n-1}{n-p-1}(1 - R^2) \tag{7}$$

And F is the significance test of regression equation, if

$$F > Fa(k, n-k-1) \tag{8}$$

Then, the explanatory variables of the model have significant effects on the explanatory variables. n is sample size, k is the number of independent variables.

The data of model 1 is the regression result when controlling variables are introduced. The data of model 2 introduces product architecture form on the basis of model 1. The results show that product architecture form has a significant impact on supply chain performance ($\beta = 0.136$, $p < 0.001$), and the degree of modularity has

Table 3 The results of hierarchical regression

Variable	Supply chains performance (SCP)		
	Model 1	Model 2	Model 3
Business scale	0.078**	0.078	0.096
Industry type	−0.067	0.067	0.006
Sales	0.001	0.001	0.004
Years of establishment	0.028	0.028	0.065*
product architecture form (PAF)		0.136***	0.330**
Modularity (M)		0.230**	0.176
Interface standardization (IS)		0.217**	0.220**
Component reuse (CR)		0.109*	0.140**
Supply chain concentration (SCC)			0.328***
Supplier concentration (SC)			0.279***
Customer concentration (CC)			0.213**
SCC × M			0.264**
SCC × IS			0.201
SCC × CR			0.215**
R	0.699	0.731	0.749
Adjusted R^2	0.479	0.517	0.531
Value of F	6.374*	11.039***	10.521***

a significant impact on supply chain performance ($\beta = 0.230$, $p < 0.01$). The degree of standardization of interface has a significant impact on supply chain performance ($\beta = 0.217$, $p < 0.01$). Component reuse has a significant impact on supply chain performance ($\beta = 0.109$, $p < 0.05$). The hypotheses H1, H1a, H1b, H1c are verified.

In model 3 supply chain concentration degree is introduced on the basis of model 2. The results show that supply chain concentration degree has a significant impact on supply chain performance ($\beta = 0.328$, $p < 0.001$), supplier concentration degree has a positive impact on supply chain performance ($\beta = 0.279$, $p < 0.001$), customer concentration degree has a positive impact on supply chain performance ($\beta = 0.213$, $p < 0.01$), and supplier concentration degree has a positive impact on supply chain performance ($\beta = 0.213$, $p < 0.01$). And the impact of supplier concentration on supply chain performance is higher than the impact of customer concentration on supply chain performance. The hypothesis H2, H2a, H2b are verified. The adjustment effect of supply chain concentration is tested and the concentration of supply chain promotes the impact of modularity on supply chain performance (0.264 > 0.230). Supply chain concentration can not adjust the impact of interface standardization on supply chain performance ($p > 0.05$), but supply chain concentration promoted the impact of component reuse on supply chain performance (0.205 > 0.109). The hypothesis H3, H3a, H3c are established, H3b is not established.

The values of R in the three models are respectively 0.699, 0.731, 0.749. Adjusted R^2 are 0.479,0.517,0.531, and $F > Fa\ (k, n - k - 1)$, therefore, the test results are valid.

4 Discussion

Based on the research of product architecture form and supply chain, this paper makes an empirical study on the relationship between product architecture and supply chain performance, and explores the impact of modularity of product architecture on supply chain performance, so as to provide theoretical basis for enterprises to choose product architecture form and improve supply chain performance.

By analyzing the survey data, this paper concludes that the form of product architecture has a significant impact on supply chain performance, and the modularity of architecture, the degree of standardization of interface and the reuse of components have a positive impact on supply chain performance, among which the degree of modularity has the largest impact on supply chain performance. Second, supply chain concentration has a significant effect on supply chain performance, as well as the reuse of components and play a regulatory role in the performance of supply chain relationship. Supply chain concentration promotes the impact of product architecture on supply chain in both paths. Therefore, product architecture with high modularity, high standardization of interface and high reuse of components has higher flexibility and responsiveness, which make enterprises can better respond to market changes, meet customer needs and improve the efficiency of supply chain.

At the same time, this study expands the theory of product architecture and verifies scholars' conjecture about the relationship between product architecture and supply chain. However, the research can be further improved, next, the authors will expand the sample and measure the variables used in the study in a more scientific way and will try to find other influencing variables to explore the relationship between product architecture and supply chain performance ulteriorly.

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The Effect of Mentoring Relationship on Engagement of Skilled Talents

Fengzhan Xiao, Long Ye, and Ming Guo

Abstract This paper, based on Social Learning Theory and Job Demands-Resources Model, discusses the influence of mentoring relationship (including vocational mentoring and social support) on the engagement (including job engagement and organization engagement) of skilled talent, from the perspective of interpersonal relationship and psychology. 151 skilled talents were selected as the research objects for investigation and analysis. The results show that the impact of mentoring relationship on engagement is positive and significant, in which the vocational mentoring dimension has a slightly higher impact on the skill worker's job engagement than the social support dimension; social support dimension has a slightly higher impact on organization engagement. The research results enrich the mechanism of engagement, and put forward feasible suggestions for enterprises to improve the engagement of skilled talents.

Keywords Social learning theory · Job-Demands-Resources Model · Mentoring relationship · Engagement · Skilled talents

1 Introduction

Skilled talents refer to professionals who are skilled in the fields of production, transportation and service, who are proficient in the fields of expertise and technology, and who have high-level hands-on skills [1]. They determine the company's production efficiency and production quality, which is the last mile of the design input to the design and output process, and is of great significance to the development of

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China's real economy. Especially with the manufacturing industry entering the era of Industry 4.0, skilled talents are becoming more and more important in the modernization competition of enterprises because of the particularity of their mastery of skill knowledge and their inability to replicate. However, due to the traditional thinking of "everything is high in reading" and "learning is good" in Chinese traditional culture, there is an inherent prejudice against skilled talents in Chinese social concepts. What follows is that it is difficult for skilled talents to take jobs as careers in their career development, which greatly affects their perception of work.

More than in the past for the study of the engagement is according to the "economic man" hypothesis, based on the social exchange theory and self-determination theory to explore the influence of employee-organization relationship [2], perceived organizational support [3], job satisfaction [4] and leadership [5] on engagement, more focused on the influence factors of employees working environment, and less consider the staff to work on its engagement of interpersonal relationships. But people are group animals, and the relationship between individuals and groups in organizations and organizations must have an impact on their behavior, that is, the "social person" hypothesis. For organizations and individuals in the enterprise, these "others" include colleagues, subordinates, leaders, and apprentices. For skilled personnel, the master as the apprentice of the apprentice's professional skills and even the leader of the career, the relationship between the apprentice and the apprentice cannot ignore the influence of the apprentice in the organization. According to the Job-Demands-Resources Model, the master often provides working resources for the apprentice, which leads the apprentice to produce a positive working state and promote his more active participation in his work role and organizational role. Based on the theory of social learning, skilled talents adjust their behavior by observing the behavior of others while at work. In the organization, the master will promote his relationship with the apprentice through psychological support, so that the apprentice will use the master as an example, imitate learning his behavior, and actively participate in his work role and organizational role. In other words, the quality of the mentoring relationship of skilled personnel will have an impact on the level of engagement.

Therefore, based on JD-R model and social learning theory, this study, from a psychological perspective, takes skilled personnel as the research object to explore the influence mechanism of mentoring relationship on engagement. This paper enriches the research on the engagement of skilled personnel in theory and provides feasible suggestions for enterprises to improve the engagement of skilled personnel in practice.

2 Literature Review and Research Hypotheses

2.1 Mentoring Relationship

Mentoring relationships have existed since ancient times, but the academic research on them started from Kram. He defined mentoring relationships as a supportive and developable binary relationship between mentors and apprentices, in which mentors are those who have been in the industry for a long time and have rich work experience, while apprentices are those who have been in the industry for a short time and lack of work experience [6]. With the in-depth study from different perspectives, many scholars have obtained different results from the study of the mentoring relationship model, including the two-dimensional model, the three-dimensional model and the network model. The earliest two-dimensional model was put forward by Kram who studied "mentor-mentee" as the research object through literature method, and it was divided into two dimensions, vocational mentoring and social support.

In Kram's two-dimensional model, the career helping dimension consists of five task-oriented elements: sponsorship, coaching, challenging assignments, exposure and visibility, protection. Through these five elements, the master provides the apprentices with professional help, such as promoting their positive job transfer, developing their work skills, arranging challenging jobs to exercise their professional skills, providing the apprentices with exposure opportunities in front of the leaders, and protecting the apprentices from harm from members of the organization. The dimensions of psychosocial support consist of four emotionally oriented elements: counseling, friendship, acceptance & confirmation, role model. The master provides psychological support to the apprentice through these four elements, such as solving the inner confusion of the apprentice to enhance emotional communication, getting along with each other as a friend during non-work period, mutual care and respect between the master and apprentice, and the master sets a correct example for the apprentice through his own behavior.

So far, Kram's two-dimensional model is still the most influential theoretical model in the field of mentoring relationship, which has been confirmed by many scholars. The exploratory factor analysis of Noe [7] and the confirmatory factor analysis of Ragins and McFarlin [8] both confirmed the existence of these two dimensions in the mentoring relationship construct. Therefore, this paper adopts this model to study the mentoring relationship.

2.2 Engagement

Engagement originated from Kahn, who defined engagement as the degree to which an employee integrates self and work roles in specific work tasks [9]. Carding scholars' research on the engagement model found that there is still no uniform standard for the model of engagement. Kahn defines engagement as a concept related to employee roles, and Saks draws on this definition. Based on the theory of social exchange, when employees obtain resources from the organization, they will reward the resources and benefits provided by the organization with different levels of participation. Saks [10] thus defines engagement as a two-way relationship between organizational members and organizations, and builds a two-dimensional model of engagement, including two independent dimensions of job engagement and organizational engagement. Empirical analysis confirms its validity and rationality. For most individuals, the two most important roles are their job roles and roles as members of the organization. In Saks' two-dimensional model, the dimension of work engagement is the degree of participation of employees in the role of their own work. The dimension of organizational engagement is the degree of participation of employees in the organizational role they undertake. This article will build on the two-dimensional model built by Saks to further study engagement.

2.3 Mentoring Relationship and Engagement

The relationship between mentoring and apprenticeship was originally a relationship established by the master or organization to help the growth and development of beginners. Its influence on apprentices is more direct and obvious. Some scholars have studied the relationship between mentoring and apprenticeship based on the perspective of power sociology and sociology of minority relations, and found that mentoring relationship promotes apprenticeship to improve salary and position promotion [11–13] and improve their professional satisfaction [11–14]. Domestic scholars are also based on the theory of social exchange and positive emotion theory to explore the positive influence of mentoring relationship on apprenticeship, and found that mentoring relationship can improve the peripheral performance of apprentice [15], innovation performance [16] and work engagement [17], reducing their turnover intention [18], promoting their organization socialization [19] and career success [20].

Although Kahn and Saks have different definitions of engagement, they all agree that a certain psychological condition of an individual is an essential cause for their engagement. At present, scholars study the influence of mentoring and apprenticeship on apprentices. Most of them are based on social exchange theory and positive emotion theory to explore the improvement of apprenticeship in apprenticeship. It is found and verified that apprenticeship will promote apprentices to produce positive work performance and results, but There are fewer scholars who have an influence on the psychology of apprentices. This article will explore the impact of mentoring relationships on apprenticeship based on social learning theory and job requirements-resource models. Mentors can enhance emotional communication with mentees through the psycho-social support dimension of mentoring relationships. According to the social learning theory, such emotional communication will influence apprentices to take their masters as role models in work or organization so as to learn their behaviors, and promote apprentices to participate more actively in their own work roles and organizational roles. When the mentor to provide professional assistance to mentees, the resources you will need to provide work, based on the Job-Demands-Resources Model, will be reduced to some extent apprentice in order to meet the job demands and the psychological pressure, lead to more actively involved in student work role, and this kind of behavior will be student learning at the same time, improve the participation of the organization's role.

Therefore, this paper proposes the following hypothesis:

H1 Career helping in mentoring relationship positively affects job engagement of skilled talents;
H2 Psychosocial support in mentoring relationship positively affects job engagement of skilled talents;
H3 Career helping in mentoring relationship positively affects organizational engagement of skilled talents;
H4 Psychosocial support in mentoring relationship positively affects organizational engagement of skilled talents.

3 Method

3.1 Sample

This study takes skilled personnel as the research object, and selects three companies in Beijing to conduct sample surveys. After consultation with the company's human resources department, the grassroots employees who meet the concept of skilled talents will be arranged to fill out the questionnaire and collect the questionnaire. A total of 180 questionnaires were distributed in this survey, and 162 were collected. 151 valid questionnaires were obtained after eliminating invalid questionnaires such as missing data. The effective rate of questionnaire recovery was 83.89%. Among the valid questionnaires collected, there were 106 subjects with mentoring relationship, accounting for 70.20%.

3.2 Scales

Based on a large number of literature readings, the scales used in the questionnaires used in this study are all developed by Chinese scholars for the maturity scale applicable to the Chinese context. All scales were based on the Likert six-level scale, with 6 points for "completely agree" and 1 point for "completely disagree". The questionnaire consists of three parts:

(1) *Basic information of the respondent:* It mainly includes the demographic characteristics variables of the disciples such as gender, age, education, etc., as well as

the characteristics of the mentoring relationship between the teacher-sex gender combination and the teacher's organization assignment.

(2) *Engagement scale:* The study selected the scale compiled by Xie [21] to measure the level of engagement of skilled personnel from the two dimensions of work engagement and organizational engagement. The scale has a total of 18 questions, including 8 questions for measuring the work engagement dimension and 10 questions for measuring the organizational engagement dimension. The Cronbach's α values of work engagement and organizational engagement in this study were 0.957 and 0.961, respectively, and the Cronbach's α value of the total scale was 0.973, both greater than 0.9, with high reliability.

(3) *Mentoring relationship scale:* The study selected the scale compiled by Yang [22]. The scale has a total of 20 questions, including 8 questions measuring the career help dimension, 9 questions measuring the psychosocial support dimension, and 3 questions measuring the similarity of the apprenticeship. This study excludes the question of the similarity of the surveyor's apprenticeship, and measures the relationship between mentoring and apprentice from the two dimensions of career help and psychosocial support. There are 17 questions. These include eight questions to measure the career help dimension and nine questions to measure the psychosocial support dimension. The Cronbach's α values for career help and psychosocial support in this study were 0.997 and 0.998, respectively, and the Cronbach's α value for the total scale was 0.999, both greater than 0.9, indicating that the measured results were very reliable.

4 Data Analysis

4.1 Difference Analysis of Engagement

In order to study whether there is a difference in the degree of engagement between mentoring and apprenticeship in skill, this study used an independent sample T test to analyze the results of the questionnaire (Table 1). The results of the study show that there is no significant difference in the degree of engagement between mentoring

Table 1 The difference test of mentoring relationship on the engagement of skilled talents

	Job engagement		Organizational engagement		Engagement	
	Have mentor	Don't have	Have mentor	Don't have	Have mentor	Don't have
N	106	45	106	45	106	45
Mean	4.752	4.517	4.68	4.331	4.712	4.414
SD	1.126	1.253	1.261	1.507	1.146	1.358
F	2.268		1.768		3.259	
Sig.	0.134		0.186		0.073	

Source Data Processing Results

and apprenticeships. However, comparing the degree of engagement and the average of each dimension, it can be seen that the skills and talents with master-student relationship are both organized and work. More skilled than skilled people without apprenticeship. It can be seen that the existence of the relationship between mentoring and apprenticeship can improve the level of engagement of skilled personnel.

The difference test of mentoring relationship on the engagement of skilled talents.

4.2 *Correlation Analysis of Mentoring Relationship and Engagement*

In order to test the correlation between the dimensions of the mentoring relationship and the dimensions of the skill-skills engagement, the Pearson correlation coefficient was used to analyze the questionnaire results (only for the questionnaire with "personal and apprentice relationship") (Table 2). From the analysis results, it can be seen that there is a significant positive correlation between mentoring relationship and skill talent's engagement ($R = 0.765$, $P < 0.01$); there is a significant positive correlation between career help dimension and skill talent's engagement ($R = 0.730$, $P < 0.01$), there is a significant positive correlation between psychosocial support dimension and skill talent's engagement ($R = 0.743$, $P < 0.01$). There is a significant positive correlation between skill talent's engagement and mentoring relationship ($R = 0.765$, $P < 0.01$); there is a significant positive correlation between job engagement dimension and mentoring relationship ($R = 0.730$, $P < 0.01$); there is a significant positive correlation between organizational engagement dimension with the mentoring relationship ($R = 0.743$, $P < 0.01$). That is to say, there is a significant

Table 2 Correlation analysis of mentoring relationship and skill talent's engagement

		Job engagement	Organizational engagement	Engagement
Career helping	Pearson	0.656**	0.726**	0.730**
	Sig.	0.000	0.000	0.000
	N	106	106	106
Psychosocial support	Pearson	0.657**	0.746**	0.743**
	Sig.	0.000	0.000	0.000
	N	106	106	106
Mentoring relationship	Pearson	0.678**	0.762**	0.762**
	Sig.	0.000	0.000	0.000
	N	106	106	106

** indicates that the correlation is significant when the confidence (two sides) is 0.01
Source Data Processing Results

positive correlation between the mentoring relationship and its dimensions and the skill talent engagement and its dimensions, and initially supports the hypothesis of this study.

4.3 Regression Analysis of Mentoring Relationship and Engagement

In order to explore whether the career help dimension (CH) and psychosocial support dimension (PS) in the mentoring relationship will affect the work engagement dimension (WE) and organizational engagement dimension (OE) in the engagement € degree, this study uses multiple linear regression method to analyze the questionnaire survey results. With career help and psychosocial support as independent variables, regression analysis was carried out with three dependent variables: work engagement, organizational engagement and engagement (Tables 3, 4 and 5).

Finally, three regression equations are obtained:

$$WE = 1.194 + 0.386 * CH + 0.327 * PS$$

$$OE = 0.313 + 0.387 * CH + 0.493 * PS$$

$$E = 0.705 + 0.387 * CH + 0.491 * PS$$

Table 3 Regression analysis of mentoring relationship and skill talent's job engagement

Model	Unstandardized coefficients		Standardized coefficients	T	Sig.
	B	Std. error	Beta		
Constant	1.194	0.423		2.824	0.006
Career helping	0.386	0.165	0.347	2.337	0.021
Psychosocial support	0.327	0.137	0.354	2.384	0.019
Model	Sum of squares	df	Mean square	F	Sig.
Regression	61.268	2.000	30.634	43.911	0.000
Residual	71.857	103.000	0.698		
Total	133.124	105.000			

Source Data Processing Results

Table 4 Regression analysis of mentoring relationship and skill talent's organizational engagement

Model	Unstandardized coefficients		Standardized coefficients	T	Sig.
	B	Std. error	Beta		
Constant	0.313	0.418		2.749	0.006
Career helping	0.387	0.163	0.310	2.370	0.020
Psychosocial support	0.493	0.136	0.476	3.631	0.000
Model	Sum of squares	df	Mean square	F	Sig.
Regression	96.940	2	48.470	71.148	0.000
Residual	70.169	103	0.681		
Total	167.108	105			

Source Data Processing Results

Table 5 Regression analysis of mentoring relationship and skill talent's engagement

Model	Unstandardized coefficients		Standardized coefficients	T	Sig.
	B	Std. error	Beta		
Constant	0.705	0.380		2.856	0.004
Career helping	0.387	0.148	0.341	2.606	0.011
Psychosocial support	0.419	0.123	0.445	3.401	0.001
Model	Sum of squares	df	Mean square	F	Sig.
Regression	80.028	2	40.014	71.171	0.000
Residual	57.909	103	0.562		
Total	137.937	105			

Source Data Processing Results

5 Results and Discussions

5.1 Research Conclusions

This study proposes four research hypotheses from the perspective of interpersonal relationship and psychological perspective, and uses the method of questionnaire survey to investigate the mentoring relationship and engagement of enterprise skilled talents. The empirical research is used to verify the proposed research hypothesis and the conclusions are drawn:

(1) There is a difference in the degree of engagement between the skilled and experienced skills and the skills and talents without the apprenticeship relationship.

The existence of the mentoring relationship can make the skilled personnel more dedicated;

(2) There is a significant positive correlation between mentoring relationship and its various dimensions (career support, social psychological support) and skill talent engagement and its dimensions (work engagement, organizational engagement);
(3) The influence of the dimensions of mentoring and apprenticeship on the degree of engagement of skilled personnel and their various dimensions is positive and significant. Among them, the influence of career helping dimension on skill talent work engagement is slightly higher than the psychosocial support dimension; the influence of the psychosocial support dimension on the skill organization's engagement degree is slightly higher than the career help dimension; the influence of the psychosocial support dimension on the skill talent engagement is slightly higher than the career help dimension.

5.2 Management Implications

It is of practical significance for enterprises to improve the professional engagement of skilled personnel by improving the mentoring relationship. Based on the research conclusions, this paper puts forward the following Suggestions from the perspective of management:

(1) Enterprises can help employees establish mentoring relationships and improve their engagement level by assigning employees with more experience to skilled personnel.
(2) The better the quality of the career help dimension of the mentoring relationship, the more resources the mentors need to provide the apprentices with work tasks, and the lower the work requirements from the side, which has a positive impact on the job engagement and organizational engagement of the apprentices; The better the quality of the psychosocial support dimension of mentoring relationships, the more effective it is to reduce the negative impact of work requirements, thus positively influencing the work engagement and organizational engagement of apprentices.
(3) Enterprises can consider establishing a training mechanism for skilled talents based on mentoring relationships, and propose some incentive measures for qualified employees who are willing to guide others to encourage them to actively develop mentoring relationships, so as to improve the engagement level of skilled talents.

5.3 Research Limitations and Prospects

There is still room for improvement in this study:

(1) Due to the homologous error in the measurement of mentoring relationship and engagement of skilled talents due to the limitation of time, future studies can assess the engagement of mentoring relationship, colleagues or supervisors of the subjects at the same time, or conduct questionnaire survey on the subjects at different points of time to make the research results more objective;
(2) The survey sampling of this study was only carried out in three enterprises in Beijing, with 92.05% of employees in the sample enterprises in China. In the future, the sample size and diversity can be increased to ensure the representativeness of the research conclusions.
(3) The study involves only mentoring relationship and engagement of two dimensions, not involved in the mediation and adjust the variables, the future can increase job satisfaction, organizational commitment and other skilled personnel intermediary variables and proactive personality, organization atmosphere of difference, such as regulating variable, a more comprehensive research to the influence of the engagement mentoring relationship mechanism.

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The Self-organization Process of Logistics Industry System

Zhihong Tian and Liangliang Chen

Abstract Self-organization mechanism can inspire the reconstruction process of logistics industry system. This paper deems that the systemic value is the order parameter of self-organization process for logistics industry system. Based on Dissipative Structure Theory, Synergetics and market theory, a phase transition model is built and evolution equations are constructed. Then, the order parameter equation is deduced by an adiabatic elimination. The order parameter equation reveals that the system value is the unique order parameter of logistics industry system. The result reveals that when the attenuation exponent of system value is more than zero, the system has the unique balance point; when the attenuation exponent of system value is less than zero, the system has two balance points; when the attenuation exponent of system changes from a positive value to zero, the system comes back the zero balance point more and more slowly.

Keywords Order parameter · Logistics industry · Systemic value · Dissipative structure · Synergetics

1 Introduction

Self-organization means that some kind of orderly system structure spontaneously forms in the absence of central control mechanism, under certain conditions. The self-organization theory is not a complete and mature unified theory, but a theory group, containing Dissipative Structure Theory, Synergetics [1], Morphogenesis,

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Chaos Theory and so on. All the above theories collectively try to reveal the mysteries of all kinds of system evolution in real world. Among them, Dissipative Structure Theory proposes the premise of self-organization process, which is that the system should be in the nonlinear region far from the balance state. The theory emphasizes two basic conditions: one is the constantly exchange of material, information and energy between the system and the environment; the other one is the non-linear interaction within the system. Synergetics is a self-organized theory studying nonlinear interaction between subsystems which will result in ordered evolution of the system structure. The theory provides dynamics methodology, and especially puts forward two important concepts—phase transition and order parameter, which try to explain how an open and erratic system evolves from a disordered structure to an ordered state, or from one ordered state to another one. In the area far from equilibrium, with the variation of control parameters, the system is close to a critical point, relationships between subsystems dominate the evolution, and coordinated movements between subsystems promote the emergence of macrostructure. The phase transition is a transformation of system aggregation state with obvious order or disorder. In abrupt phase transition, order parameters are produced by nonlinear interaction of system internal variables, due to subsystem's contribution to the cooperative movement. Before the phase transition, order parameters should be zero. At the critical point, order parameters increase sharply. When they occur, they begin to control other variables, and dominate the system evolution process. Therefore, identification and investigation of order parameter is a good breakthrough point for the study of system evolution process.

In order to investigate the order parameter of logistics industry system, the self-organizing evolution process should be analyzed firstly. Then, the specific issues could be translated to mathematical problems. The paper is organized in the following way. In Sect. 2, we present our theoretical assumption that systemic value is the unique order parameter in the evolutionary process of logistics industry system, based on the analysis of related works. Section 3, an analytical framework for logistics industry system is proposed. Section 4 lays a foundation for following research with the analysis of self-organizing evolution process. In the section, two typical dissipative features about the logistics industry system—open and nonlinear are analyzed, and the phase transition process is discussed by building a model. The role of order parameter in the process is also shown here. In Sect. 5, the specific issues are translated to mathematical problems. Evolution equations with 6 parameters are constructed. Then, by four-stage classification method and adiabatic elimination, the order parameter equation is deduced which reveals that the systemic value is the only order parameter of logistics industry system. It also reveals that when the attenuation exponent of system value is more than zero, the system has the unique balance point; and when the attenuation exponent of system value is less than zero, the system has two balance points; and when the attenuation exponent of system changes from a positive value to zero, the system comes back the zero balance point more and more slowly. Finally, summary is dedicated in Sect. 6.

2 Related Works and Theoretical Assumption

Literature about order parameter in logistics industry is relatively scarce. The researches of order parameter and phase transition of markets are dominated by traditional market field. In the field of enterprise system, entrepreneurship [2], innovation [3] and R&D [4] are considered to be the order parameter. In financial market, asset price may be a global variable with the critical role of coordinating the actions of agents who are otherwise independent. In electricity market, rate of generation is deemed as the order parameter [5]. In S&P stock market, an order parameter can be interpreted within an agent-based model. However, the above researches confuse the key concept that the order parameter is macroscopic parameter. Order parameters are not formulated by a single enterprise or by administrative departments. They are formed in the cooperation and competition within system. Each element in the system has different contribution, such as internal resources, management procedures, customer value, and core competence. In the interaction between all elements, order parameter set is born, and in the end, the unique order parameter arises.

Reference [6] defines a simple statistic s to capture the degree of correlation in the system. s can be seen as the order parameter of the system because if $s = 0$ there is no correlation (a disordered state), whereas for $s \neq 0$ there is correlation among stocks (an ordered state). However, the statistic only has theoretical significance but no practical significance.

Through the analysis of the above related works, we find that there are not reasonable assumptions and certificates about the order parameter of logistics industry. As a typical market, there is a value network, in which, value is transferred effectively. In the value network, enterprise members create value, and pass it to consumers who are the source of value network, because consumers' demands activate the whole network. In the value network, value delivery follows value exchange and transaction cost theory, and is associated with the value creation process and transaction process. Value distribution is according to the ratio of resources and the size of the contribution of member enterprises. Value reflects the dominant nature of logistics industry system—the processes of value increment and value transfer. The core competence of enterprises reflects the abilities for value capture and value creation. Hence, in this paper, a theoretical assumption is proposed that systemic value is the unique order parameter in the evolutionary process of logistics industry system.

3 An Analytical Framework

Complex system theory is a comprehensive theory containing self-organization theory, nonlinear theory and complexity theory and so on [7]. In complex system theory, it has been discovered that there is a significant relationship between the behaviour of agents and their underlying system structures. Using complex system to study logistics industry can enhance the in-depth understanding of system structure. Hence, we present a system analysis framework for logistics industry [8].

The system is constituted by parts and relationships between them. Parts represent the elements in the system, and the relationships represent the interaction between system elements. Logistics industry is a complex system, and its complexity reflects in the following areas:

(1) The system has a huge number of elements, and its system structure is complex and presents a variety of different characteristics. The emergence and demise of elements that have the life-cycle characteristic is very common. The relationships among elements are also dynamic changed [9].
(2) There is no one dominant organization to control and organize the other members in the logistics industry system [10].
(3) The system is formed in a self-organizing way through the actions and interactions of actions and interactions of actors involved, as they occur over time. They are continually being made and remade (or not) through ongoing structuring and restructuring processes.
(4) The system does not have clear boundaries or a dominant centre. For example, all individuals and organizations relating to logistics industry can be involved into a huge and complex system. However, in order to reduce the difficulties of research and simplify models, system's scope should be determined first logistics enterprises and customers can compose the system. A big enterprise and its co-operators compose a community system, and so on. The system perspective on logistics industry has wide-ranging implications for understanding the behaviours, the opportunities and strategies available to participants.
(5) The macro environment includes the social-cultural space in which businesses operate. Businesses depend on the level of knowledge and the institutional framework, the legal institutions and moral norms. Social-cultural norms and laws set includes various rules for behaviour that affect interactions between firms and the kinds of relations that can be formed and not formed. These include contractual, property rights and trade practices act. Also, the development of specialization and division of labour will have important externalities through its impacts on people's lives, the environment, social institutions, politics and power, religious and other values, as well as social life in general.
(6) Time plays a central role in explaining and understanding exchange. Business relations develop over time and they are path-dependent. Buyers and sellers actively take into account what has happened before and they also form plans and have expectations of what is likely to happen in the future, both of which affect their decisions in the present. The state of the subject (person or organization) changes over time.

4 The Self-organizing Evolution of Logistics Industry System

4.1 Dissipative Structure of Logistics Industry System

Because of the entropy increasing function of thermodynamics, the system must maintain the existing structure and access to the possibility of evolution, through constantly exchanging material, energy and information with the outside world. In ecological system, it is called metabolism, and in system science, it is called dissipative structure. logistics industry system is a typical dissipative structure, because there are two typical dissipative features about the system—open and nonlinear.

(1) *The Logistics industry system is open:* From birth moment, logistics industry is not just an isolated system or industry, but a huge industrial network which involves governments, organization, society, public, media, and many related industries. Although the concept of "logistics industry system" comes from the market, it still has many special differences. First, logistics industry system deepens the link between industries. A new system is forming gradually. The logistics industry system is more complicate and ecology, and its stability, robustness, self-organizing and evolutionary mechanism are different from traditional market.

(2) *The logistics industry system is nonlinear:* Logistics industry has the characteristic of nonlinear, which means that complicated nonlinear interactions exist among subsystems or internal elements, and the developments of time and space dimensions reflect nonlinear characteristics. Typical examples are the network effect, external effect, path lock-in effect, winner-take-all effect and exponent effect, etc. Take a kind of instant messaging product as an example, the more users it has, the higher market value it has, and the higher value each user obtains, which is the network effects and network externalities. Due to the isolation between different instant messaging product user networks, which product a new user will choose could depend on the choice of his friends around. Hence, there is a local product aggregation and may also extend to whole market, namely, path lock-in effect and winner-take-all effect.

4.2 Phase Transition Model of Logistics Industry System

Figure 1 shows the model of phase transition process of logistics industry system. The area circled by dotted line is the system. The dotted line means that the border is not fixed and clear, but vague. Logistics industry penetrates into all walks of life. It constantly is absorbing funds, talent, technology, policy, laws and regulations, information, culture, and so on, from the whole social economic environment. The environment is the platform, namely "external control variable".

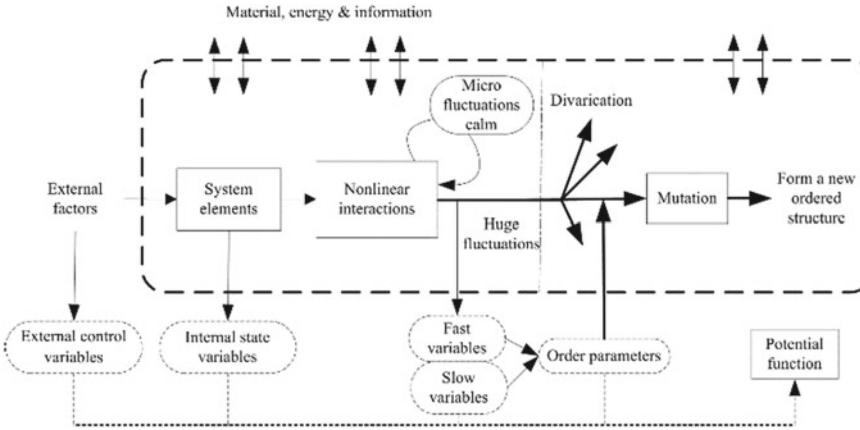

Fig. 1 Phase transition model of logistics industry system

Under the huge fluctuations, system comes into the critical region, and is faced with many bifurcation path choices. Finally, under the guidance of the order parameter, a branch is selected, and the phase changes suddenly.

5 Order Parameter Analysis

5.1 Evolution Equations of System and Order Parameter Equation

From Fig. 1 we can see that, the system evolution is related to the role and position of current state parameters—energy level, fluctuation, time, space and other related factors. One of the purposes of systematic is to find macroscopic variables from lots of micro variables of system. System motion equations are built to describe dynamic behaviors and evolution of system. At the same time, potential function is introduced in the research. At any time, if the state of a system depends on a set of variables $x_1, x_2, \ldots, x_n$, $(x_1, x_2, \ldots, x_n)$ are called state variables of system. For the function $f(x_1, x_2, \ldots, x_n)$, each stable state of system maps to minimum point of function $f(x_1, x_2, \ldots, x_n)$. The function is so called potential function. Whether in nature or human society, potential functions dominate the development of systems.

The evolution equations are as follows:

$$\frac{dQ}{dt} = F(\alpha, Q, k, t) + E(\alpha, t) \tag{1}$$

$$\frac{dX}{dt} = -\frac{\partial E}{\partial Q} \tag{2}$$

Q System state variables, which are functions of time and space;
$\frac{dQ}{dt}$ State change rate;
F Drive of system, which is a multivariate function of state variables, space and time;
α Order parameter of the system;
k Space vector;
t Time vector;
E Potential function;
X Adjoint vector of Q, which is also a function of time and space.

For an open system that connects with outside, the internal physical quantity distribution is a function of space and time. There are material flow and energy dissipation at macroscopic level. In order to describe the self-organization system, the system is divided into N_e units with a length of e, and the volume is $\Delta V_{ri} = e^d$ (d is the space dimension of the system) [11]. The physical quantities describing the process of self-organization are $X_1, X_2, \ldots, X_n$ which are functions with time t and space r. Hence, the system state vector $\boldsymbol{X}(r, t)$ could be described as:

$$X(r, t) = \{X_1(r, t), X_2(r, t), \ldots, X_n(r, t)\} \tag{3}$$

In stationary state, the state of the unit i at time t can be stood for the average location X (r_i, t) of ΔV_{ri}. The whole system can be described by a set of state configurations:

$$\{X(r_i,\ t)|_i = 1, 2, \ldots, N_e\} \tag{4}$$

Under critical state, there are n units participating in the change, and the (3) can be described as:

$$X(r_i, t) = \{X_1(r_i, t), X_2(r_i, t), \ldots, X_n(r_i, t)\} \tag{5}$$

The motion equation can be written as follows:

$$X_j = F_j(X) + K_j(t) \quad (j = 1, 2, \ldots, n) \tag{6}$$

In (6), $K_j(X) = K_j(X_1, X_2, \ldots, X_n)$ is a nonlinear function of $\{X_1, X_2, \ldots, X_n\}$. Equation (6) can be seen as a motion equation of n nonlinear damped oscillators. $F_j(X)$ can be seen as the driver of damped oscillator j. $K_j(t)$ is the random disturbance. Expand (6) as follows:

$$X_j = \sum\nolimits_{k=1}^{n} a_{jk} X_k + f_j(X) \quad (j = 1, 2, \ldots, n) \tag{7}$$

In (7), $|f_j(X)|$ is a nonlinear function with X. For steady point, the matrix is negative, so there is a set of new coordinates (q_1, q_2, …, q_n) making the matrix be diagonalizable.

$$\begin{cases} \dot{q}_1 = -r_1 q_1 + g_1(q_1, q_2, \ldots, q_n) \\ \dot{q}_2 = -r_2 q_2 + g_2(q_1, q_2, \ldots, q_n) \\ \quad\quad\quad \cdots\cdots \\ \dot{q}_j = -r_j q_j + g_j(q_1, q_2, \ldots, q_n) \\ \quad\quad\quad \cdots\cdots \\ \dot{q}_n = -r_n q_n + g_n(q_1, q_2, \ldots, q_n) \end{cases} \tag{8}$$

In the equation, $\{q_1, q_2, \ldots, q_n\}$ includes order parameter u. We can find the order parameter from many system variables by adiabatic elimination method. When Haken studied the evolution mechanisms of open systems, he found that not all parameters of system play the same role in evolution process, but only order parameters can do. Parameters playing a crucial role in evolution process are slow variables; parameters which cannot play a crucial role in evolution process are fast variables. Fast variables evolve fast, arrive the phase transition point early, and no longer change. Hence, we let the first derivatives with respect to time of fast variables be equal to 0. Then, plug it into other slow variables equations to get evolution equations about order parameters.

Suppose that u is the order parameter which controls other parameters, and let $q_1 = u$. When the system tends to the critical point, based on the Synergetic, $r_1 \to 0$, and other $r_j > 0$ ($j = 2, 3, \ldots, n$) which are limited. Then adiabatic approximation is used to obtain the order parameter.

$$\dot{q}_2 = \dot{q}_3 = \ldots = \dot{q}_j = \ldots = \dot{q}_n = 0 \tag{9}$$

Equation (8) can be changed to:

$$\begin{cases} -r_2 q_2 + g_2\big(u, q_2, \ldots, q_j, \ldots, q_n\big) = 0 \\ \quad\quad\quad \cdots\cdots \\ -r_j q_j + g_j\big(u, q_2, \ldots, q_j, \ldots, q_n\big) = 0 \\ \quad\quad\quad \cdots\cdots \\ -r_n q_n + g_n\big(u, q_2, \ldots, q_j, \ldots, q_n\big) = 0 \end{cases} \tag{10}$$

Solve the simultaneous equations:

$$q_2 = h_2(u), \ldots, q_j = h_j(u), \ldots, q_n = h_n(u) \tag{11}$$

Take (11) into (8), and obtain the order parameter equation:

$$\dot{u} = -r_1 u + g_1\big(u, q_2, \ldots, q_j, \ldots, q_n\big) = -r_1 u + g\big[u, h_2(u), \ldots, h_j(u), \ldots, h_n(u)\big] = G(u) \tag{12}$$

In the equation, $G(u)$ is a nonlinear function of order parameter u.

5.2 Determine the Order Parameter of Logistics Industry System

In logistics industry system, we determine optional system state parameters and relationships between them by Delphi method. From Fig. 2 we can see that, investment Q_1 is impacted by system value and policy and law. Innovation ability Q_2 is impacted by enterprise culture, system value and technology, and so on. The graph can be described as Table 1.

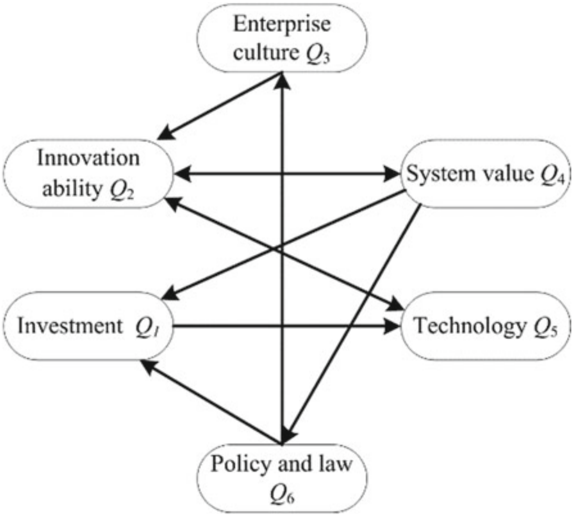

Fig. 2 Relationships of state variables of logistics industry system

Table 1 Relationships of state variables

	Investment Q_1	Innovation ability Q_2	Enterprise culture Q_3	System value Q_4	Technology Q_5	Policy and law Q_6
Investment Q_1					√	
Innovation ability Q_2				√	√	
Enterprise culture Q_3		√				
System value Q_4	√	√				√
Technology Q_5		√				
Policy and law Q_6	√		√			

State equations are as follows, and $-k_i$ ($i = 1, \ldots, 6$) refers to the attenuation parameter of state parameter.

$$\begin{cases} \frac{dQ_1}{dt} = -k_1 Q_1 + f_1(Q_1, Q_4, Q_6) \\ \frac{dQ_2}{dt} = -k_2 Q_2 + f_2(Q_2, Q_3, Q_4, Q_5) \\ \frac{dQ_3}{dt} = -k_3 Q_3 + f_3(Q_3, Q_6) \\ \frac{dQ_4}{dt} = -k_4 Q_4 + f_4(Q_2, Q_4) \\ \frac{dQ_5}{dt} = -k_5 Q_5 + f_5(Q_5, Q_2, Q_1) \\ \frac{dQ_6}{dt} = -k_6 Q_6 + f_6(Q_4, Q_6) \end{cases} \tag{13}$$

Since the state equations with 6 parameters are too complex, we analyze the relational structure of parameters further based on accessible matrix, and classify them by their significance. The adjacency matrix can not only reflect the direct relationships between the parameters in the logistics industry system, but also reflect the indirect relationships between them. If the parameter Q_i impacts on Q_j directly, $a_{ij} = 1(a_{ij} \in \boldsymbol{A})$; or else $a_{ij} = 0$. If Q_1 impacts on Q_2, and Q_2 impacts on Q_3, Q_1 also impacts on Q_3 indirectly. Establish the adjacency matrix $\boldsymbol{A}$ in accordance with Table 1.

$$\mathbf{A} = \begin{bmatrix} 0\,0\,0\,0\,1\,0 \\ 0\,0\,0\,1\,1\,0 \\ 0\,1\,0\,0\,0\,0 \\ 1\,1\,0\,0\,0\,1 \\ 0\,1\,0\,0\,0\,0 \\ 1\,0\,1\,0\,0\,0 \end{bmatrix} \tag{14}$$

Calculate the accessible matrix $\boldsymbol{R}$:

$$\boldsymbol{R} = \boldsymbol{I} \cup \boldsymbol{A} \cup \boldsymbol{A}^2 \cup \boldsymbol{A}^3 \cup \boldsymbol{A}^4 \cup \boldsymbol{A}^5 \cup \boldsymbol{A}^6 \tag{15}$$

Then, we get a Boolean matrix $\boldsymbol{M}$ from the transformation of $\boldsymbol{R}$:

$$\mathbf{M} = \begin{bmatrix} 1\,1\,1\,1\,1\,1 \\ 1\,1\,1\,1\,1\,1 \\ 0\,0\,1\,1\,1\,1 \\ 0\,1\,1\,1\,1\,1 \\ 1\,1\,1\,1\,1\,1 \\ 1\,1\,0\,1\,0\,1 \end{bmatrix} \tag{16}$$

According to $\boldsymbol{M}$, all parameters influenced by F_i compose an accessible set $E(V_i)$, and all parameters impacting on F_i compose a set $S(V_i)$. All parameters both impacting on and influenced by F_i compose a set $T(V_i)$, which is the intersection of $E(V_i)$ and $S(V_i)$. The three sets are shown in Table 2.

Table 2 E(V_i), S(V_i) and T(V_i)

V_i	$E(V_i)$	$S(V_i)$	$T(V_i)$
1	1–6	1, 2, 5, 6	1, 2, 5, 6
2	1–6	1, 2, 4, 5, 6	1, 2, 4, 5, 6
3	3– 6	1–5	3–5
4	2– 6	1– 6	2–6
5	1– 6	1–5	1–5
6	1, 2, 4, 6	1– 6	1, 2, 4, 6

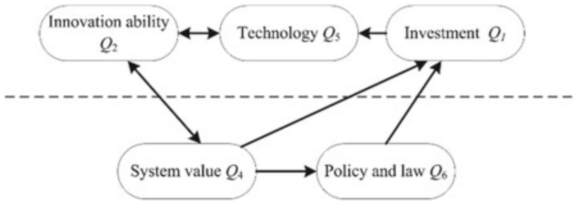

Fig. 3 The relational structure of parameters

A “Fourstage classification method” is introduced to analyze the relational structure of parameters. The top class meets $T(V_i) = S(V_i)$, the second class meets $E(V_i) > S(V_i)$, the third class meets $E(V_i) < S(V_i)$, and the bottom class meets $T(V_i) = E(V_i)$. According to the classification method, the top class contains Q_1, Q_2 and Q_5, the second class contains Q_1, Q_2 and Q_5, the third class contains Q_4 and Q_6, and the bottom class contains Q_4 and Q_6. Hence, the relational structure of parameters is as following Fig. 3.

From Fig. 3 we can see that, the most direct parameters are innovation ability, technology and investment, but the essential reasons lay in system value and policy and law. The essential parameters, which are the basic reasons for system evolution, make a tremendous impact on direct parameters. Hence, order parameter should be found therein.

Then, the two parameters are left as the optional parameters for order parameter. Let system value Q_4 is q_1 and policy and law Q_6 is q_2, and the Haken model is as follows.

$$\begin{cases} \frac{dq_1}{dt} = -k_1 q_1 - \lambda_1 q_1 q_2 \\ \frac{dq_2}{dt} = -k_2 q_2 + \lambda_2 q_1^2 \end{cases} \tag{17}$$

In the model, k_1 is the damping coefficient of system value q_1, and k_2 is the damping coefficient of policy and law q_2. Both of them are control variables. λ_1 and λ_2 are adjustment parameters. λ_1 is the attenuation parameter of system value. Hence, λ_1 is positive and λ_2 is the growth parameters of technology. If $k_2 >> k_1$, q_2 is fast variable and q_1 is slow variable. Let $\frac{dq_2}{dt} = 0$, by adiabatic elimination, we can get the following equation.

$$q_2 = \frac{\lambda_2 q_1^2}{k_2} \tag{18}$$

Plug (18) into (17):

$$\frac{dq_1}{dt} = -k_1 q_1 - \frac{\lambda_1 \lambda_2 q_1^3}{k_2} \tag{19}$$

The corresponding potential function is:

$$E(q_1) = \frac{k_1 q_1^2}{2} + \frac{\lambda_1 \lambda_2 q_1^4}{4k_2} \tag{20}$$

The above process proves that whether a state parameter becomes an order parameter depends on the following four essential conditions:

(1) The order parameter is a macro parameter. It can describe behaviors of the system, and conform to the superposition principle.
(2) Order parameter is the characterization and measure of system, and comes from within of system.
(3) Order parameter dominates the other variables of the inner system, and controls the evolution behaviors of system.
(4) Order parameter has relative stability. Now, we have proved that value is the order parameter of the logistics industry system.

5.3 Discussion about Order Parameter

The phenomenon that a stable point becomes two stable points is called symmetry broken instability. Each stable point corresponds to a stable state of system. Due to random fluctuations, the system deviates from the state of $q_1 = 0$, and jumps to one of the two stable states from unstable state. E reflects the ordering level of system. The evolutionary process could be shown as Fig. 4.

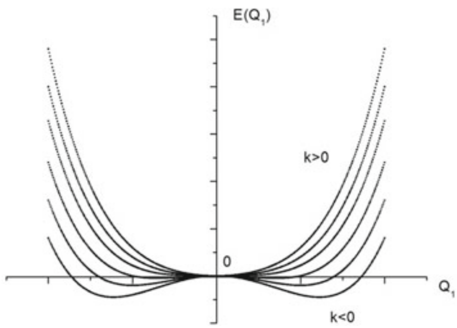

Fig. 4 Potential function curves against k

When $k_1 > 0$, the potential function of system has only one minimal point, which is the asymptotical stable point of system. Though due to random fluctuations the system deviates from stable state, it comes back the original position fast. When k_1 tends to 0 gradually, the curve of the system becomes more and more smooth. At the moment, the system comes back the original position more slowly, which is “critical slowing down”. The random fluctuation in “critical slowing down” is “critical fluctuations”. When $k_1 < 0$, the potential function has two minimal points, and which point the system enters depends on random fluctuations.

6 Conclusion

So far, there are very inadequate studies about logistics industry system with an order parameter perspective. Our study is a multi-disciplinary research intersected by Dissipative Structure Theory, Synergetics and market theory. We believe that the investigation of order parameter will lead to profound understanding on the operating principles of logistics industry.

In this paper, we deem that systemic value is the order parameter of logistics industry system. Dissipative structure and phase transition are analyzed and evolution equations are constructed. Then, parameters are classified by the fourstage classification method, and the order parameter equation is deduced by adiabatic elimination.

The order parameter equation reveals that the value is the only order parameter of logistics industry system. It also reveals that when the attenuation exponent of system value is more than zero, the system has the unique balance point; and when the attenuation exponent of system value is less than zero, the system has two balance points; and when the attenuation exponent of system changes from a positive value to zero, the system comes back the zero balance point more and more slowly.

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An Evaluation Method Based on Neighbors for Node Importance in Maritime Network

Liangliang Chen and Zhihong Tian

Abstract In this paper, in node importance in maritime network area there is a new evaluation model has been proposed. Comparing with other analogous methods, this evaluation method reflects a more comprehensive evaluation result. The model of this method is based on two different way about the evaluation factors which the node's strength and the influence of its neighbor nodes. Then, in 2016, we investigated Lloyd's List Intelligence's case of the world's top 100 ports through container throughput. We find that the distribution of node strength follows power law distribution and the distribution of node degree follows exponential distribution. At last, the parameters of the model are determined by the case study.

Keywords Node importance · Maritime network · Complex network · Transmission efficiency

1 Introduction

At present, the development of container transportation in the world is very fast. With the development of container transportation, maritime transport network has gradually become the most complex network in the transport industry. Deliberate attacks and random failures on any single node in this network may not seem like a big problem, but they may lead to cascade failures of the entire network system. From the perspective of global system, the focus of investigating the most important

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nodes in a network is the trend from causal analysis at the local component level to network research.

Network is a type of model that describes natural and engineering systems. A network can be seen as a collection of basic individuals with certain characteristics and functions, and individuals are interrelated and mutually influential. We can use the concept of graph to describe the network: node can be regarded as the basic functional unit; edge or link is to describe the interrelationship between nodes. The state of each node is determined by two factors: one is the characteristics of each node itself; the other is the effect of the node associated with it. We must point out that the network can be described by the model of the graph, but the network is not only a graph, it also has a state and carries certain functions, such as the Internet to interconnect computers, in this sense, the network can see Make a diagram with a certain state and function.

There is little research which has been conducted on the basis of the evolution of the network structure, and the industrial cluster is a system in which related members exist in a certain area in the form of a network. However, the evolution of network structure of clusters has attracted the attention of many scholars. However, the existing literature regards the network as a static existence, homogenizing the relationship between organizations, ignoring the relationship between the dynamic evolution of cluster network structure and corporate behavior. Therefore, from the perspective of multinational company embedding, the process of evolving the network structure of logistics industry clusters can break through the limitations of existing research objects, expand and deepen the research on the development and evolution mechanism of multinational companies affecting the industrial clusters of host countries. The company provides certain theoretical support for its own development.

Among the achievements of complex network research, researchers have found that most practical complex networks have the following basic characteristics: statistical behavior of network behavior, complexity of node dynamic behavior, sparseness of network connections, and connection structure. Complexity, the complexity of the space-time evolution of the network. The above five characteristics reflect the complexity of the actual network. On the one hand, it has the characteristics of disorderly evolution, on the other hand, it also has an evolutionary feature that increases the degree of order. Unfortunately, for the time being, scientists have not yet given a precise definition of complex networks. From the research of these years, the reason why it is called a complex network generally includes the following meanings: First, Topological abstraction of a large number of real complex systems; secondly, it is at least perceived to be more complex than regular networks and random networks, because we can easily generate rules and random networks, but for now, there is no simple way to generate complete Networks that conform to real statistical characteristics; finally, because complex networks are the topological basis for the existence of a large number of complex systems, its research is believed to help understand the critical issue of “complex systems complex.”

People would reach little consensus on the “node importance” concept because it is an intrinsically vague concept. Scholars in the field of Social Network Theory such as Freeman [1] deem that in social network, the importance of some node is related to "centrality" of the node. Freeman [1] reviewed the concept and measure of "centrality" and proposed three indexes of measure for point centrality. "Degree" is a proper measure which can be used to measure the communication activity in a network. "Betweenness" reflects the frequency that a node is just between pairs of other nodes on the shortest paths. "Closeness" can be used to reflect the independence or efficiency of the network communication. These three indexes of measure are referenced to three different structural attributes. Besides the centrality and degree, reference [2] defines another potential verification of network position's role in port performance is the comparison of the degree with the hub dependence level.

Apparently, single centrality cannot reflect the whole profile and only provides partial information about nodes. In reality, due to the complex relationships and large-scale nodes of networks, the critical to rank nodes by incorporating multi-criteria. However, different scholars have different ideas about incorporating multi-criteria, and each method has some defects. Then, a new idea about importance contribution of node importance from adjacency nodes is proposed [3, 4]. They deem that a node with important neighbor nodes should be more important than one with weaker neighbors.

According our research, we proposed an evaluation model which is newest for node importance in maritime network. This model is built on the above idea. In this model, Understand and learn two evaluation factors: the strength of the node itself and the important contribution of the nodes other than the node to the network. Then, an empirical research is carried out. A maritime network comprised of global top 100 ports by container throughput in 2016 is investigated. The case study indicates that this model can reflects a more comprehensive evaluation result than the methods of only one centrality factor.

This paper is structured as we follows. In Sect. 2, the influence factors of node importance are analyzed and rules of node importance comparison are proposed. In Sect. 3, the evaluation model is built and the case study is carried out. Finally, Sect. 4 summarizes the contribution of this paper.

2 Influence Factors of Node Importance

2.1 Centrality

(1) *Degree centrality analysis*

The most intuitive topological measure of centrality is given by the degree: more connected nodes are more important [5]. Degree centrality is defined as the number of links incident upon a node. Degree is often viewed in terms of the imminent risk of node for catching whatever is flowing through the network. The following formula defines the absolute value of the degree centrality:

$$C_D(n_i) = d(n_i) = \sum_j x_{ij} = \sum_j x_{ji} \tag{1}$$

The value of x_{ij} is 0 or 1, which indicates whether actor j and i has a relationship or not.

(2) *Betweenness centrality analysis*

Betweenness centrality is defined as the proportion of the shortest paths between every pair of nodes that pass through the given node towards all the shortest paths. It is based on the idea that a node is central if it lies between many other nodes, in the sense that it is traversed by many of the shortest paths connection couples of nodes [6]. Nodes that occur on many shortest paths between other vertices have relatively higher betweenness than those nodes that do not.

(3) *Closeness centrality*

Besides the above two ways, there are other definitions of centralities. Reference [7] deems that the degree centrality describing the "importance" of a specific node does not provide complete information for understanding the structural properties of transport networks. In order to address this problem, various measures of structural centrality have been used to quantify the importance of a port. Closeness centrality is a type of centrality measure D_i, which is defined as the average shortest path length from a certain node i to all other nodes as follows:

$$D_i = \left(\sum_{j \neq i} l_{ij}\right) / (N - 1) \tag{2}$$

where l_{ij} is the shortest path length between port i and j. This quantity is a centrality measurement of node i; the small value of D_i suggests that it is convenient from node i to other nodes.

2.2 Degree and Degree Distribution

The degree of a node in a network (sometimes referred to incorrectly as the connectivity) is the summation of connections or edges a certain node has to other nodes. An adjacency matrix $\boldsymbol{A}$ represents the links connecting each pair of nodes. The element a_{ij} of the adjacent matrix $\boldsymbol{A}$ equals to 1 if there is a link from node i to j or 0 if there is no link between i to j.

$$k(i) = \sum_{j \neq i} a_{ji} \tag{3}$$

The degree distribution $P(k)$ of a network is then defined to be the fraction of nodes in the network with degree k. Hence if there are an aggregate of n nodes in a particular network and n_k of them have degree k, we have $P(k) = n_k/n$. The degree distribution is very critical in studying all real networks, since it can reflect directly the basic structure and feature of network, such as random property or scale-free property.

2.3 Average Shortest Path Length

Average shortest path length is one of the three most robust measures of network topology, along with its clustering coefficient and its degree distribution. The average shortest path length d can be defined as [8–10]:

$$d = \frac{L}{L_{\max}} = \frac{\sum_{i<j} l_{ij}}{\binom{n}{2} L_{\max}} = \frac{6 \sum_{i<j} l_{ij}}{n(n+1)(n-1)} \tag{4}$$

where l_{ij} is the shortest path length between node i and j. $L_{\max} = (n + 1)/3$ is the maximum value of L that can be achieved by a connected network.

2.4 New Rules of Node Importance Comparison

Although there is no consensus on the node importance concept, some intuitive ideas are recognized by scholars. The ideas can be described by some rules, and the basic concepts must be extracted from the intuitions [5]. For the similarity of nodes In real life, the study of the similarity between elements in complex systems has become one of the most important tasks at present. For example, the similarity of users can be effectively marketed according to different characteristics. The similarity between long texts or short texts can be used to recommend similar content. The similarity between proteins can be studied biologically to analyze the relationship between proteins. At present, the research on node similarity mainly focuses on community partitioning and link prediction. The essence of community division is actually to analyze the attribute similarity and structural similarity of nodes, and classify nodes with higher similarity into the same community.

Based on the above analysis of the factors affecting the node importance, some conclusions are derived as follows. Firstly, assuming that two nodes are indifferent, such as node A and node B are in the same position, the two nodes are equal in importance. Secondly, if node A has a betweenness that is not smaller than the node B, and also the node A is of greater importance than node B. Thirdly, if node A has a closeness that is not smaller than that node B, the node A is of greater importance than node B. Fourthly, if node A has a degree that is not smaller than node B, the node A is of greater importance than node B.

Above factors are all caused by the nodes themselves. However, we deem that there should be two sources of node importance, which are the source from the node itself and the source from other nodes. Considering the characteristics of maritime network, we can deem that the greater the port throughput is, the more important the port is, and more important the neighbor that the port links more important the port is.

Port throughput is a very important factor during this study. When forecasting port throughput, it is necessary to collect traffic, economic and social related information and outline the collection of information. General traffic information includes port cargo, container throughput, sub-category throughput, cargo and passenger turnover, cargo and passenger traffic, and other relevant information in the port. Economic and social data includes materials such as GDP, per capita GDP, total import and export trade, population, disposable income, major foreign trade enterprises and demand, and future economic transportation planning. Data analysis of the collected data, extraction of data and data that have an impact on port throughput and then collation.

Two factors can be set to measure the importance of a given port—node strength and the neighbors' effect on a given port. In marine network, main factors affecting port size include throughput, turnover, number of berths, ship types, etc. Among those factors, the throughput is generally agreed to be an index to measure the size of the port. In addition, the data of throughput of ports is readily available. Therefore, in this model, the value of node strength could be instead by throughput. On the other hand, the neighbors' effect on a given port contains two parts—distance between neighbor and the node and the neighbor node strength. The farther away the neighbor from the node is, the smaller the influence is.

In short, new rules of node importance comparison are proposed as follows. Firstly, if node A has a node strength that is not smaller than the node B which we estimated, and node A is of greater importance than node B. Secondly, if node A is closer to an important node than node B is, the node A is of greater importance than node B.

3 The Model

3.1 Model Expression

In order to study the geometric characteristics of different complex networks such as social networks, power grids, metabolic networks, computer networks, etc., many generation algorithms have been proposed. In these network generation models, two types of models that are consistent with the real network: the WS small world model proposed by StrogatZ and the (BA) model proposed by Barabasi & Albert have been extensively studied, and the random network model was originally studied, and the E of the random network An R model has been in use for nearly forty years, so it is important to understand these basic network models.

Under an analysis in the previous paragraph, the model expression of node i can be deduced as follows.

$$I_i = S_i \cdot F_i \tag{5}$$

where I_i refers to the importance of a given node i. And S_i is the strength of node i. F_i refers to the neighbors' effect on a given node i and $F_i = \sum_{j=1, j \neq i}^{n} f_{ij}$, where f_{ij} is the importance contribution from node j to node i, and $f_{ij} = e_{ij} \cdot S_j$.

Then formula 1 can be converted as follows:

$$I_i = S_i \left(\sum_{j=1, j \neq i}^{n} e_{ij} \cdot S_j \right) \tag{6}$$

Here, an important concept is introduced into the model—the transmission efficiency.

The transmission efficiency e_{ij} $(i, j \in n)$ from node i to node j is inversely proportional to the most effective path length of two nodes. An interaction between the two nodes directly depends on the transmission efficiency between the two nodes. Since there is a complex nonlinear relationship between the transmission efficiency and the importance contribution which is from a node to another node, this relationship can be described by a nonlinear function.

$$e_{ij} = \frac{1}{d_{ij}^{\alpha}}, \alpha \in \{1, \ldots, n\} \tag{7}$$

where α is a control parameter of transmission efficiency. A transmission efficiency matrix $\boldsymbol{E}$ with n nodes is as follows:

$$E = \begin{bmatrix} e_{11} & \cdots & e_{1n} \\ \vdots & \ddots & \vdots \\ e_{n1} & \cdots & e_{nn} \end{bmatrix} \tag{8}$$

Finally, the model expression of the node importance in a network is derived as follows.

$$I = E \cdot S \cdot S \tag{9}$$

where $\boldsymbol{E}$ is a transmission efficiency matrix, and $\boldsymbol{S}$ is the node strength vector.

In this model, all parameters are known except the control parameter α. Depending on the value of α, the model outputs different results. Therefore, in the following case study, an appropriate value of α will be look for.

3.2 Case Study

In the case which we estimated, we first investigated the global container throughput in 2016, and the maritime network of the world's top 100 ports. Many scholars and majors have divided the port division stage and basically formed a consensus. The division of the development stage of contemporary port transportation is generally divided into the following three points: first, port development policies, strategies and attitudes; second, the scope and extension of port business activities, especially information; and third, the integration of port business activities and organizations. The current global port policy which is to make more sustainable development and environmental impact an important part of the port. Emphasis on the harmonious coexistence of ports, people and nature, maximizing the use of port economic activity resources and reducing the impact of ports on the surrounding environment as an important measure, and adhere to the path of sustainable development. For the purposes of this paper, the new phase of port development is also reflected in the slowdown in port throughput growth. In particular, many of the ports used in this paper have entered the ranks of the world's major ports, and are among the world's foremost in terms of many hardware facilities and indicators. Pay attention to the construction of the port in a soft environment, and increase efforts in port logistics, port information, port services, second-hand ship market and construction of shipping centers.

Top 20 shipping companies at the beginning of 2016 are selected as samples which account 80% of global market share. Choose at the beginning of 2016 world top 20 shipping companies as samples, accounting for 80% of global market share, these data can be a good representation for the whole global market, and the data source is Alphaliner. The network topology map is obtained as the following Fig. 1.

To measure the network structure, we can investigate the distribution of some features of nodes in the network. In the maritime network, there are two major features of nodes—node degree also with node strength. In addition, in real network, there are two common distributions—exponential distribution $P(k) \sim e^{-k}$ and power distribution $P(k) \sim k^{-\gamma}$. A network with the scale-free property follows the power-law distribution $P(k) \sim k^{-\gamma}$, which means a few nodes in the network will have a huge number of links and most nodes will have fewer links. We could name the first ones "hub nodes". Here, the degree k means the total number of links of a given node. This scale-free property of the network may result which in a very high dependency during the hub nodes. An exponent γ of the power function, which is important, reflects the characteristic and shape of the network topology. Smaller exponent γ is, fewer the hubs who dominate the network are.

The distributions and corresponding fitting curves of node strength and node degree are as following Fig. 2. In the figures, x-axis represents the node degree or node strength, y-axis refers to the probability of sharing the corresponding number. The distribution which in this case of the node strength follows a power-law distribution, and the fitting function is $P(k) \sim 1.06 * k^{-0.95}$. R-square is 0.97567. From the fitting curve and the value of R-square, we can deem that fitting is good. However,

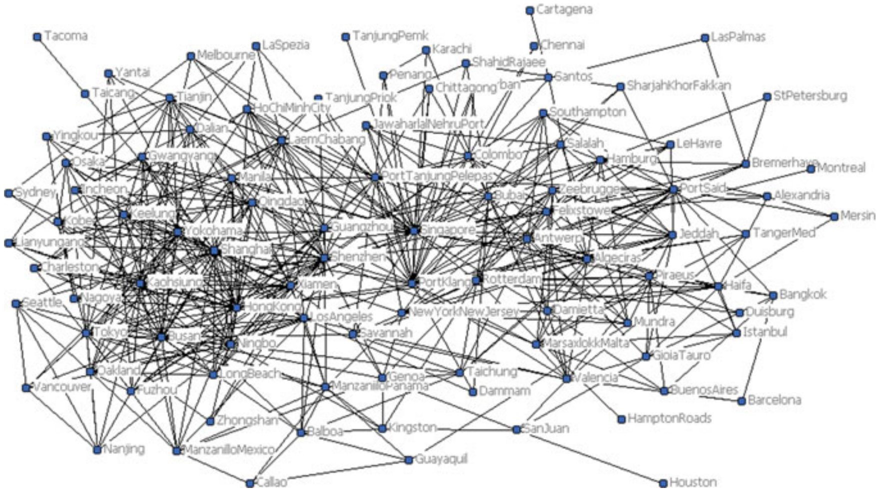
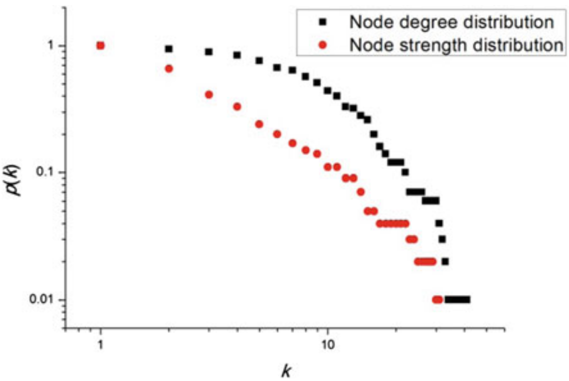


Fig. 1 The network topology map of the case

Fig. 2 Distributions of node degree and node strength



the node degree distribution follows an exponential distribution which is different from power-law distribution. The fitting function is $P(k) \sim 1.22 * e^{-k/10.47} - 0.034$, and the R-square is 0.99207. From the fitting curve and the value of R-square, we can deem that fitting is good.

In addition, from the figure we can see that, the distribution probability of node strength drops faster than that of node degree which means that in this maritime network, the concentration of throughputs is more obvious than that of route numbers, and most ports in the network have a small throughputs and a few ports have large throughputs. It is proved again that the characteristics of a node are important to the importance of that node.

In the index system of port logistics influencing factors, it is difficult to use every possible influencing factor of the previous analysis in the analysis of the influencing factors of the port logistics industry. So far, the logistics and port logistics statistics only have basic oyster transport volume and freight turnover, port throughput, container throughput, berth quantity, 10,000 berths, and total passenger and freight traffic by different modes of transportation. Data, other logistics related indicators, and port logistics related indicators statistics have no public information, this situation is not commensurate with the rapid development of China's port logistics. Since the related logistics and port logistics data statistics work is relatively backward, we should consider the selection of statistical indicators when selecting indicators. There are three main principles to be selected: the operability of the measurement data, the strong correlation between the indicators and the port logistics industry, and the principle of mutual independence between indicators and indicators.

3.3 Results and Analysis

Here, we will search an appropriate value of α. In the model, α is a control parameter which can be adjusted. We vary the value of α from 1 to 6, and different node importance ranks are obtained as following Fig. 3. From the figure we can see that ranks of node 1 to node 20 float up and down with the change of α. When $\alpha \geq 2.5$, the float becomes smoother than $\alpha < 2.5$. For that, we think that $\alpha = 2.5$ is suitable.

When $\alpha = 2.5$, the top 5 most important ports are Singapore, Shanghai, Hong Kong, Shenzhen and Ningbo. Although the throughput of Singapore port ranks second, the importance of Singapore port ranks first. Because the port connects the Pacific Ocean and India ocean, and links to many other important ports of other continents. The strategic position of Singapore is very important to the whole maritime network. The throughput of Port Klang ranks 13th, but the importance of it ranks 9th, because the port which is located in the Malacca strait, is the largest port in Malaysia, and is the ideal port of call in routes between Far East and Europe, having obvious competitive advantage in the shipping market.

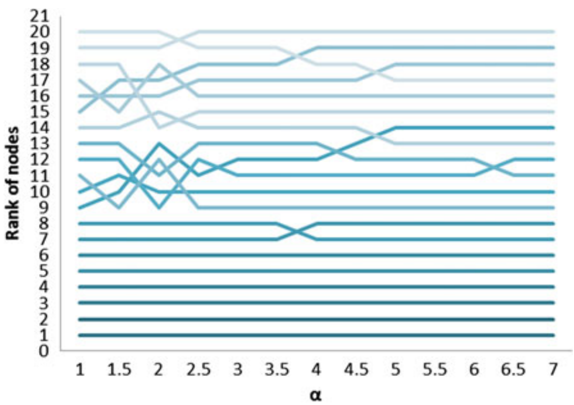
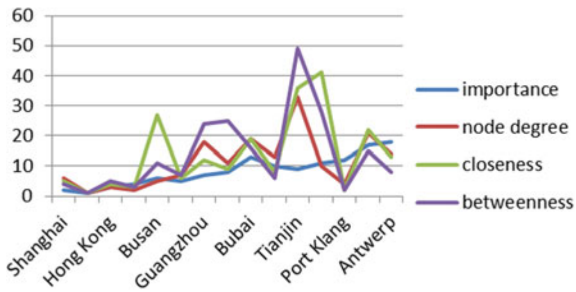


Fig. 3 Trends of node importance rank according to varied α

Fig. 4 Ranks of betweenness, closeness, node degree, importance



In Fig. 4, ranks of nodes from index 1 to 15 by betweenness, closeness, node degree, importance are compared. In this figure, x-axis refers to the ranks of nodes, and y-axis represents the ports. The betweenness, closeness, node degree, and importance of Singapore port all rank first. However, the ranks of many ports by different methods are different. For example, the betweenness and closeness of Port Klang rank a lot higher than these of Kaohsiung port, but the ranks of importance are similar. From this figure, we can see that, only one method of betweenness, closeness, or node degree cannot get a reasonable ranking. Since several of the methods we have studied reflect only one aspect of multiple features of a node in the current network, we can use different methods to get different conclusions on the ordering. The current key node heuristic algorithm attempts to find an efficient and reasonable algorithm from different angles and even different fields, but still has many limitations and incomplete considerations. The main problem is that the definition of the importance of the node itself is not accurate. In heuristic algorithms such as coloring, SN, LSS, VoteRank and HC, the importance of the node itself plays a big role in the result of the algorithm. Most of the algorithms adopt the degree of centrality to measure the importance of the node. The calculation time complexity is very low, and the first few nodes with the largest selection in the scale-free network and the exponential network can effectively destroy the network. In particular, in the infectious disease propagation model, if the infection probability is very low, then Centrality is more capable of propagation than other indicators, but the degree only considers the number of neighbor nodes, not only does not consider more local information such as second-order or higher-order neighbors, and does not distinguish neighbor nodes, that is, each The degree of influence of the neighbors on the importance of the nodes is the same, but it is not the case. The HC algorithm selects the nodes with the highest similarity with the other nodes in the cluster. Although the number of paths between the nodes is considered, only some The number of local paths of the internal nodes of the community, without the global information of the integrated nodes.

The evaluation method of this study considers the mutual influence of adjacent nodes on the basis of analyzing the strength of the nodes themselves, so that comprehensive conclusions can be considered.

4 Conclusion

So far there are few works about the port importance of the maritime network in the view of network aspect. Our study is a multi-disciplinary research with a combination of maritime and network science. It is our belief that the study will lead to further study and research that will reveal the undetected vulnerability of maritime network.

Marine transportation accounts for more than 90% of the global volume of imported and exported goods. Marine transport efficiency has a major impact on global economic development, international politics, and socio-economic exchanges. In particular, China's current "The Silk Road Economic Belt and the 21st-Century Maritime Silk Road" policy, China's Maritime Silk Road policy also affects current international ocean transportation. At the same time, ocean transportation efficiency is also highly susceptible to sudden events such as natural disasters and political changes. Therefore, quantitative assessment of the anti-jamming capability of the marine transportation network structure and proposed targeted improvement proposals have important practical significance for improving the efficiency of marine transportation and enhancing the scientific decision-making of marine transportation infrastructure investment.

Several influence factors of node importance are analyzed which are all caused by the nodes themselves. However, in the network of maritime network, we deem that there should be two sources of node importance, which are the source from the node itself and the source from other nodes. Considering the characteristics of maritime network, new rules about port throughput and the importance of neighbors are proposed. Then, the evaluation model is presented.

Firstly, we find that the distribution of node intensities and power-law distributions in the study are echoed, and the distribution of node degrees is also echoed by the distribution of indices. From figures, the distribution probability of node strength drops faster than that of node degree which means that in this maritime network, the concentration of throughputs is more obvious than that of route numbers, and most ports in the network have a small throughputs and a few ports have large throughputs. It is proved again that the characteristics of a node are important to the importance of that node.

Secondly, we find that when the control parameter α in the model expression $\geq$2.5, the float of ranking becomes smoother than $\alpha < 2.5$. When $\alpha = 2.5$, the top 5 most important ports are Singapore, Shanghai, Hong Kong, Shenzhen and Ningbo. Each evaluation method only reflects a single aspect of multiple features of the nodes in the network, and different evaluation methods will also affect the results obtained. So our research can get better results based on the evaluation method of the node itself and the influence of other nodes.

In our research, the traffic volume of vessels of ports are neglected which should be subject to research in the future. Furthermore, the traffic volume of vessels of port is mainly about that in this situation the number of ships in the fixed-water maritime-regulated ship is measured by the number of ships in a certain water area within a certain period of time. For example, the annual traffic volume of inbound and outbound vessels is the number of ships entering and leaving the port during the year. The prerequisite for our research is stable for a certain period of time, and the dimension of time should be considered for future work.

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Inflation Disagreement and Its Impact on Stock Market Volatility, Unemployment Rate and Financial Soundness

Hameeda Akhtar, Rukhsana Jabeen, and Syed Zulfiqar Ali Shah

Abstract Disagreement about expected inflation is an emerging phenomenon in Finance and Economics. This real effect side of the economy and real consumption growth volatility. This paper contributes by providing its impact on stock market volatility, unemployment rate and financial soundness. It is cross-sectional study, due to unavailability of data from all over the world data is taken only from 84 countries for the year 2015. This study provides evidence that disagreement about expected inflation significantly affects these factors. The findings provide implication for policy makers and forecasters. This study contributes that uncertainty and volatility can be diminished by improving survey forecasting and reducing disagreement about expected inflation among survey respondents and an open future avenue for researchers.

Keywords Inflation disagreement · Unemployment rate · Financial soundness

1 Introduction

The discussion about inflation agreement or disagreement about inflation expectation is growing in the modern world. Disagreement about expected inflation is due to differences in the belief of survey respondents. Survey respondents rely on different information model while formulating expected inflation. Disagreement arises when survey respondents incorporate information differently. It was proved that inflation

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disagreement and forecasted inflation are strongly correlated for consumer's forecaster and not correlated for professional forecasters [1]. There is two main suggestion presented about inflation expectation and its disagreement. Firstly, the resources could be wrongly allotted if there is inflation disagreement which is a contradiction of the assumption of the information model of rational expectations, which is the feature of the information which is a sticky model [2] and noisy model [3]. Secondly, forecasted inflation disagreement is taken as a proxy if through anchoring procedure expectation about inflation is formed and monetary policy is formed [4].

As theoretically and empirically present a result that inflation disagreement supposed to increase the yields of interest rates and interest rates volatilities and it is found that inflation disagreement is positively associated with the trading of securities in the area of fixed income and the growth uncertainty of consumption [5]. As it has shown that inflation disagreement effect real side of the economy [6], so here it is needed to discuss that it does affect central bank decisions in terms of monetary policy i.e. unemployment rate, stock market volatility and financial soundness of a country.

Based on the Phillips curve, which is almost related to economics, i.e. the supposition that for a short time the monetary policy has a direct impact on the outcomes. The rules and laws of Keynesian economists included the effect of rational expectations and presented solid microeconomic reasons for the short-term effect of monetary policy. The core idea was that prices are sticky. Also, when the prices are sticky the power of real spending increases which increase the real output.

2 Literature Review

For central bank due to their monetary policy decisions disagreement about expected inflation can be the interested factor for a state bank. Firstly, too much volatility about forecasted inflation can increase services cost and it is not directly associated with present inflation [7]. A salient reason to set a low level of inflation is that it is nearly more associated with more forecasted inflation [8, 9], hence theoretically and empirically provides a link between the level of inflation to inflation uncertainty. If there is a more dispersed expectation, it displays more deviation in forests. Consequently, the output is significant cost-oriented due to inflation uncertainty. Secondly, if there is better targeting about the expectation the result can be in lesser disagreement about expectation of inflation.

There are certain reasons that cause disagreement such as uncertainty of macroeconomic news because all information cannot be incorporated and updated in the forecasting. It was suggested that after a specific time updating adjustment made [10, 11]. Moreover, the way to decrease the disagreement is to increase the updating intervals to incorporate news into inflation expectations, but it is seen that quantity of sudden macroeconomic news is more as compared to the frequency of updating the expectations, providing more disagreement about inflation most of the times. According to researcher people focus on prices which they pay more frequently and more recently while formulating belief about forecasting of prices [12]. Consequently, all related economy factors effect by disagreement [13].

After the great recession inflation forecasters displayed more disagreement in inflation forecasting that disagreement depends upon time intervals, as some forecaster forecasted for a shorter period and others forecasted for longer period of time. This variation among forecasters increases variation in a decision related to fiscal policy and monetary policy [14]. As inflation disagreement positively related to central bank policies & trading securities. It is found in Australia that disagreement responds has no significant relation with news shocks about macroeconomic and consumer survey forecaster has more disagreement than professional surveys and for consumer forecaster the level of disagreement and the level of inflation expectations align together as compare to professional forecaster [1]. As inflation expectation effect our investment decision and consumption decision. Inflation expectation provides a wedge between nominal and real interest rates, whereas inflation disagreement effect real side of the economy [5].

The central banks all around the world are increasingly providing forward guidance to the public to get an effective decision which assist efficiently anchor inflation expectations. Since the central monetary authority of the country, the State Bank of Pakistan (SBP) enhance implementation of the reliable inflation targeting as a high-level goal in its strategic plan for 2016–2020, it is crucial to forecast inflation as accurately as possible [15]. Banks are making more efforts to incorporate future expectations more accurately to decrease disagreement.

It is theoretically and empirically proved the association between inflation disagreement and interest rates yields, asset prices like derivatives and swaps and inflation disagreement also increases real consumption volatilities and real interest rate volatilities [5]. It is proved that under bounded rationality concept, survey expectation and rational expectation both determine inflation expectation under new Keynesian Phillip Curve theory [16].

As policy makers and forecaster analyzed the volatilities lying in stock markets. An investigation by researcher described the association between the volatilities of macroeconomic variables and unexpected behavior of the stock market and concluded that macroeconomic uncertainty could be found by analyzing inflation behavior [17]. The other investigation by researcher presents an important finding that unexpected stock market behavior affected by the whole of the economy [18]. As the uncertainty in a macroeconomic variable like GDP, GNP, inflation, exchange rates and interest rates variable increases uncertainty. So, disagreement about inflation effect stock market volatility. A great economist presented empirical proof of this relationship in the UK market [19]. Further extends this working by [20]. Recent research in Pakistan economic by analyzed the relationship between inflation and unemployment rate [21]. Iranian researcher also analyzed the same effect and showed negative association between them [22]. In response to the financial crisis, the Financial Soundness Indicator was launched by the IMF in 2000 [23]. The primary object of the FSIs is to help make financial systems more transparent, especially in those developing countries where the availability of such data has been limited.

2.1 Theory

According to the extended model by Phillips. Inflation is composed of two elements:

- Future expected inflation rate,
- The difference between the present price and the highest price level.

According to Phillip curve inflation expectation is affected by central bank announcement so monetary policy also affected by if volatility exist among inflation expectation i.e. inflation disagreement effect monetary policy, i.e. production level, GDP, unemployment rate, financial soundness and exchange rate. Inflation expectation data purely depend upon past information, its mean survey respondent relies on past information about the expectation of inflation data, and they do not look any price development of inflation [24].

Forecasted future cash flow is the independent factor and the factor which depends on it is current inflation. Hence NKPC describes by calculating dividend through the discounted way inflation depends upon discounted assets price. More volatility in inflation expectation is led by more disagreement about expected inflation. Accordingly, thus inflation disagreements also affect stock price volatility.

2.2 Research Model of the Study

IV Inflation Disagreement (i.e. disagreement about expected inflation)
DV SM Volatility, Unemployment Rate, Financial Soundness.

2.3 Hypothesis

(a) *Inflation disagreement and stock market volatility*

See Fig. 1.

As the stock price volatility is measured and studied in many types of research. The movement in stock market prices describes the prosperous condition of the economy.

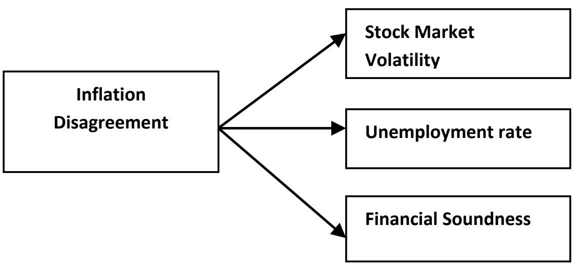

Fig. 1 The relationship between inflation disagreement, stock market volatility, unemployment and financial soundness

The variation in the prices of the economy helps the analyst for making policies and forecasting [24]. To understand the effect of disagreement about expected inflation on variation in stock market prices according to the fisher effect helps us to understand the uncertainties while calculating the present value of future cash flow. Because these are calculated based on of expected inflation thus disagreement about expected inflation does affect stock price volatility and project evaluation can differ due to this disagreement. The more disagreement about expected inflation the more uncertainty to calculate asset price- model. So, we posit,

H1: There is a significant association between Inflation Disagreement and Stock Market Volatility.

(b) *Inflation disagreement and unemployment rate*

The Phillip curve describes the relationship between the unemployment rate and expected inflation. A constant curve describes the optimal point to select inflation at certain unemployment rates which help to set the goal of macroeconomic policy [25]. The relationship between the unemployment rate and inflation has remained the main area of research for many years. According to theory more unemployment means low demand for labor and its more supply, hence the price of labor goes downward [26]. Along with Phillip Curve unemployment rate or inflation rate affect the economy condition. Disagreement among individuals might arise due to the discrepancy of analyst beliefs [5].

Analyst different opinion about the Phillip curve could be due to volatile growth in GDP. Thus, real GDP growth effect unemployment rate. Thus, uncertainty in real GDP growth effect unemployment rate [1]. Moreover, inflation disagreements effect macroeconomic variable and their decision to forecast, which can directly affect GDP growth and unemployment rate. Fluctuation in unemployment rate indicates unstable economic conditions, we posit,

H2: There is a significant association between inflation disagreement and unemployment rate.

(c) *Inflation disagreement and financial soundness*

Financial soundness is the key element of stable economic condition. As higher inflation has a negative relation with profitability, financial soundness also effects by inflation. High inflation and high unemployment rate effect price of securities which effect asset index and security trading [27]. According to NKPC, there three models of information and in a sticky model to receive and refine the information is expensive [28]. Analysts update their information for forecasting. Differences in processing of different information model finally create inflation disagreement among forecasters. This inflation disagreement has a direct impact on fiscal and monetary policies forecasting. The financial stability indicator indicates how financially health is the economy, showing that the macroeconomic variable has direct impact of FSI. Macroeconomic variable affected by inflation expectation and inflation disagreement. As it is proved that inflation disagreement the real affect side of the economy so inflation disagreement can affect the financial soundness of the country. So, we posit,

H3: There is a significant relation between Inflation Disagreement and Financial Soundness of the country.

3 Research Methodology

3.1 Data Collection and Sampling Technique

This research is empirical (Quantitative) and the purpose of this research is hypothesis testing. The target population is all countries. However, the sample is drawn in way to select all those countries which data is available about all variables. All variables measured by taking secondary data from the web sites of the IMF and the global economy. As Inflation disagreement is the squared standard deviation of expected inflation rates for the year 2015. Cross-sectional data is used for the period of 2015 for 84 countries.

3.2 Data Analysis Methods

Data coding is performed with the help of Stata. Structural equation modeling and descriptive statistics are performed in Stata through these equations.

3.3 Econometric Equations

$$\text{a. SMV} = \beta_0 + \beta_1 \text{InfDis} \tag{1}$$

$$\text{b. UnemR} = \beta_0 + \beta_1 \text{InfDis} \tag{2}$$

$$\text{c. FS} = \beta_0 + \beta_1 \text{InfDis} \tag{3}$$

4 Results and Discussions

See Table 1, Figs. 1, 2, 3 and 4.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Inflationd disagreement	84	10.01595	18.3897	0.00052	116.7006
Volatility	83	15.80795	7.4373	4.02	54.46
Unemployment rate	84	12.91881	11.28377	1.93	45
Financial soundness	83	16.01397	7.80298	1	40

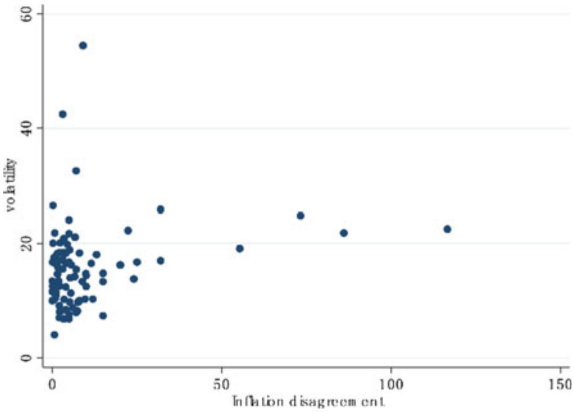

Fig. 2 Graphical relationship between infdis & SMV

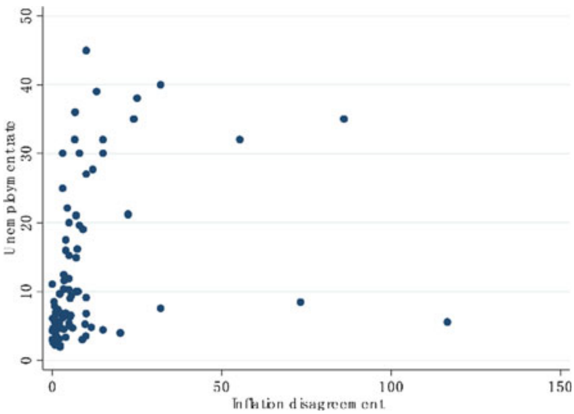

Fig. 3 Graphical relationship between infdis & Unemprate

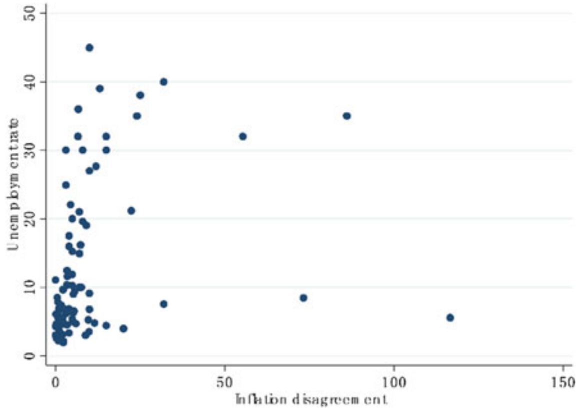

Fig. 4 Graphical relationship between Infdis & FS

Table 2 Analysis of Eq. 1

Description	Standardized coef.	Std. err	Z	p > lzl	95% CI.
Infdis	0.2174	0.1033	2.10	0.035	0.0149–0.420
Constant	0.0796	0.2546	0.31	0.755	−0.419–0.578
Volatility	0.9526	0.0449			0.868–1.0449

4.1 Regression Analysis between Inflation Disagreement and Stock Market Volatility

As coefficient $\beta = 0.2175$, the stock market volatility shows 21.5% variation in inflation disagreement (Table 2).

Moreover ($p = 0.035$), which indicate significant relationship. It supports hypothesis H1, which is consistent with recent research. The result shows that inflation disagreement has a direct positive relation with stock market volatility.

Moreover, if inflation disagreement increases by 1%, the stock market volatility increases by 21.7%. Too much disagreement in inflation leads too much volatility in the stock market. Its low inflation expectation needs precautionary measures. It needs professionals' suggestion to view and improve the forecasting.

4.2 Regression Analysis between Inflation Disagreement and Unemployment Rate

As coefficient $\beta = 0.2751$, unemployment rate shows 27.51% variation in inflation disagreement (Table 3).

Table 3 Analysis of Eq. 2

Description	Standardized coef.	Std. err	Z	p > |z|	95% CI.
Infdis	0.275	0.098	2.78	0.005	0.0812–0.469
Constant	0.231	0.165	1.39	0.164	−0.094–0.556
Unempl rate	0.9243	0.0544			0.823–1.0373

Table 4 Analysis of Eq. 3

Description	Standardized coef.	Std. err	Z	p > |z|	95% CI.
Infdis	−0.3004	0.097	−3.08	0.002	−0.491–0.109
Constant	1.170	0.223	5.24	0.000	0.732–1.608
F. soundness	0.9097	0.0586			0.801–1.03

Moreover ($p = 0.005$), which indicate significant relationship. It supports hypothesis H2, which is consistent with previous results. That unemployment rate has direct relation but with inflation disagreement. As there is much disagreement in inflation expectation it can affect the unemployment rate that can affect production level and economical condition of a country. If inflation disagreement increases by 1% unemployment rate increases by 27.51%. The unemployment rate is the most salient factor of the economy. Unemployment rate affect the economic decisions. This is consistent with previous research and Phillip Keynesian Curve which shows a direct relationship between inflation and unemployment rate.

4.3 Regression Analysis between Inflation Disagreement and Financial Soundness

As ($\beta = -0.300$), which indicate significant negative relationship. Moreover ($p = 0.002$), which indicate a significant relationship. It supports hypothesis H3. It is obvious that too much variation in inflation disagreement effect practitioners' decisions and policy decisions maker which affect the financial condition of the country. Financial soundness is negatively correlated with inflation disagreement. If inflation disagreement increases by 1% financial soundness decreases by 30.04% (Table 4).

5 Conclusion and Suggestion of the Study

This is the first study which describes how stock market volatility, unemployment rate and financial soundness of any country are related to inflation disagreement. This is the first study which describes the relationship among these variables. This study shows analysis of inflation disagreement and its impact on unemployment rate, stock market volatility and financial soundness. Our study shows a positive relation for the unemployment rate and stock market volatility and negative relation for financial soundness. That is consistent with the recent study presented by [5] that not only real inflation but inflation disagreement also increases volatilities in securities and other economic factors. As according to New Keynesian Phillip curve, it was demonstrated that unemployment rate and inflation has trade-off relation, because when inflation increases workers demand higher income, and when their demand is not fulfilled, they left the job thus increases the unemployment rate. Our result is consistent with NKPC and [4] findings. The result shows that if there is much disagreement about inflation expectation, the financial soundness of a country can be at risk. So, disagreement of consumers or professionals can disrupt financial conditions of a country in terms of its financial soundness.

Based on our study findings there is certain fruitful implication for policy makers. Policy makers and many economists can foresee unemployment rate changes, stock market volatility and financial soundness performance by looking at a disagreement about expected inflation of survey forecasters. Economist or policy maker can foresee risk by looking at inflation disagreement. If there is too much disagreement policy-maker should identify which factor causing too much variation. Because major fiscal and monetary policy decisions depend upon inflation expectation. However, there are certain study limitations. As it is cross- sectional study future research should be panel data which should include more year's data, to see variation among variables. As it is emerging research in the area of inflation disagreement, so the future study should explore the effect of other variables of monetary and fiscal decisions. Our study describes possible outcomes of inflation disagreement. Future study should elaborate possible antecedent of inflation disagreement.

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Risk Management of Investment and Financing of Urban Rail Transit PPP Project in China

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Abstract Using PPP mode to build urban rail transit projects can solve the government's financial problems and mobilize social capital at the same time, which can achieve a win-win situation of public and private. Practice shows that reasonable risk management is the key to the successful PPP mode. The paper focuses on the risk management of PPP mode in urban rail transit projects in the following aspects: risk identification, risk assessment, risk sharing and risk response strategies and actions in the whole process of investment and financing of the project which means the whole process of the project. First, the risk checklist method and the work breakdown structure method are used to get the risk list of China's urban rail transit PPP project. Secondly, the questionnaire is distributed and the expert scoring method is used to sort the occurrence probability and damage degree of the risk items in the list of risk. Then, Pareto's law is used to assess the key risk factors, important risk factors, secondary risk factors. Thirdly, on the basis of existing research, the principle of risk sharing is clarified and various risk subjects in PPP projects of urban rail transit are determined. For the risk which needs to commit jointly, to use AHP method to determine the specific share ratio, and make Beijing Metro Line 4 "force majeure risk" as an example. Finally, put forward the strategies and measures to deal with all kinds of risks. This study has practical value in providing guidance for the practical work of risk management of urban rail transit PPP project.

Keywords PPP mode · Urban rail transit · Risk identification · Risk assessment · Risk sharing

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1 Introduction

Under the policy environment of the National Development and Reform Commission and the Ministry of Finance actively implementing the PPP model, at present, some cities in our country have already turned from the model of bank loans to multiple investors from the government investment model in the past. PPP mode through the government and social capital to participate in the project investment, construction, operation, share the project risk, the PPP model through the market-oriented investment and financing stage development of various financing channels. The key to the smooth promotion of urban rail transit project under PPP mode is to link the demand of both supply and demand of capital reasonably, and reduce the risk factors to the project management by sharing the risk among the project participants reasonably. The impact of the above can be achieved by risk management in the process of investment and financing of urban rail transit projects under the PPP mode.

The purpose of this paper is to solve the following problems: the possible risks and key risk elements in the process of investment and financing of urban rail transit projects; How the participants in the urban rail transit PPP project share the risk in the project risk management determines the proportion of a certain risk item, and what coping strategies and actions can be taken by the participants in the project when facing the risk. This study has practical value, and provides guidance for the practical work of urban rail transit project risk management under the PPP model.

2 Literature Review

Academic research on the PPP model increasingly rich, from the meaning, nature and the feasibility of extending to the PPP mode risk management research of the problem. About risk identification and evaluation research, Henjewele studied the process of multi-stakeholder consultation and management of the PPP project environment, transfer the public from the profit space of PPP project to the ownership center [1]. Through research, Rafter put forward the principle of risk sharing in PPP projects. The risk is likely to get appropriate returns [2]. Some scholars tried to show that the concept of PPP mode can also be used to evaluate PPP public risks as a set of undetermined rights [3]. Iyer and Sagheer thought based on risk probability and impact the severity degree of risk sorting is indispensable in the process of the PPP project risk management [4]. In terms of overall risk management, Zou and Wang, explored the risk management framework of the life cycle of PPP model to realize the value of balancing money and interests between different partners, including the public and end users [5]. At home and abroad to the public, including urban rail transit project, the construction of the PPP mode risk management research has achieved many good results, but there is lack of the following:

2.1 Quantitative Study of Risk Sharing Ratio

For the quantitative study of risk sharing ratio is relatively small. Scholars at home and abroad in the PPP project risk allocation research is mainly qualitative research, and the object of study for a single subject or two departments, namely the government and the private sector [6].

2.2 Risk Response Measures

Most previous research of project risk management in urban rail transit from the face various risks in the process of the whole project, summarizes the classified or segment for risk response measures, the results are often more general [7].

3 Research Contents and Ideas

3.1 Fundamental Ideas

This paper studies the investment and financing risk management of urban rail transit projects in China under the PPP model, which will be studied from the following aspects: risk identification and assessment, risk sharing, risk response. Finally, the general methods of investment and financing risk management of urban rail transit projects in China under the PPP mode are given.

3.2 Risk Identification and Assessment

This paper combines the risk checklist method and the work decomposition structure method to find and identify the risk items of investment and financing of urban rail transit projects in China under the PPP mode from the various risks of the PPP model. In the first part of the questionnaire, the probability of occurrence of risk items in the risk list and the degree of damage were ranked by expert scoring method. The key risk factors, important risk factors and secondary risk factors were evaluated by Pareto's law.

3.3 Risk Sharing

Based on the principle of risk sharing reached by the academic community, this paper analyzes which risks should be borne by the government and the private sector in the list of risks, respectively, by using the literature summary method and according to the principle of risk sharing reached by the academic community. According to the principle of risk sharing, the AHP analytic hierarchy process (AHP) is used to determine the specific proportion of risk sharing, and the AHP criterion layer is established according to the principle of risk sharing. Taking the "Force Majeure risk" of Beijing Metro Line 4 as an example, a questionnaire II is issued. In order to determine the share ratio of government departments, project companies and financial institutions to the risk of non-resistance, the expert scores are used to analyze and apply the examples.

3.4 Risk Response

The risk response can be negotiated to establish that the contract terms should include the risk management mechanism, the definition of rights and responsibilities, and the pricing and price adjustment mechanism; the reserve should include specific measures such as unforeseen expenses, reserve capital, and standby loans. According to the strategy of risk response, the main body of risk differentiation puts forward the coping path of the main risk project, and how each project participant carries out the risk response in the PPP project is clear.

4 Risk Assessment

4.1 Questionnaire Related and Investigation

The purpose of the questionnaire is to collect data from experts in the industry to assess the occurrence probability and hazard degree of various risk factors. Mainly divided into two parts, the first part is the background of the interviewee. The second part is the risk occurrence probability and the hazard degree evaluation, uses the 5-point system score method.

In this questionnaire, experts who have academic research or practical experience in the field of urban rail transit PPP project are selected as the object of interview. With the help of "questionnaire Star" network to distribute electronic questionnaires and individual visiting experts issued paper questionnaires, 18 valid questionnaires were successfully recovered.

Table 1 Risk items with the highest probability of occurrence and the greatest degree of hazard

Risk factor	Occurrence probability		Sort	Risk factor	Extent of injury		Sort
Public sector (E)	Average value	Standard deviation			Average value	Standard deviation	
High financing cost	3.64	1.02	1	Force majeure	4.57	0.99	1
Approval access/delay	3.24	1.15	2	Engineering/design quality	4.52	1.16	2
Completion risk	3.22	0.83	3	Market demand change	4.46	0.39	3
Construction cost overrun	3.17	1.04	4	Poor quality of service	4.45	1.29	4
Engineering/operational change	3.16	1.09	5	Insufficient income	4.43	0.71	5
Operating cost overrun	3.09	0.70	6	Approval access/delay	4.42	0.90	6
Insufficient income	3.08	1.00	7	Expropriation/public ownership	4.39	0.73	7
Market demand change	3.03	1.14	8	Increase in the cost of materials (private)	4.35	0.94	8
Improper design	3.01	1.19	9	Site safety	4.18	1.08	9
Increase in the cost of materials (private)	2.92	1.28	10	Engineering/operational Change	4.17	0.92	10

4.2 Key Risk Factor Assessment

By sorting out and calculating the results of the questionnaire, Table 1 shows the 10 risk items with the greatest probability of occurrence and the greatest degree of harm.

In this paper, according to Pareto's rule, the contribution rate of each risk factor to the influence is calculated according to the order of the influence degree from large to small (the contribution rate of a certain risk item = the influence degree of a certain risk item/the sum of the influence degree of each risk item). According to the cumulative contribution rate, the risk factors were divided into three categories: A was the key factor, 0/80%/B was the important factor, and 80/90% was the accumulative contribution rate (ABC). C is the secondary factor, the cumulative contribution rate is 90–100%.

5 Risk Sharing of Urban Rail Transit Project Investment and Financing in China Under PPP Model

5.1 Principle of Risk Sharing

By using the method of literature research, this paper summarizes the representative views of domestic and foreign scholars on the principle of risk sharing in PPP projects of urban rail transit.

(1) *The principle of symmetry of risk sharing and control force:* requires the participants with weak control power to cooperate and promote actively without affecting the overall interests of the project.

The basic principle of risk sharing is to leave the risk to the participants who have the most control over it. If the project participants can fully understand the risks to be borne, foresee and avoid risk occurrence in advance, correctly assess the risk impact; if the risk occurs, can control and reduce the impact of the risk in a timely manner; After the risk occurs, the risk can be dealt with reasonably, then the participant is the controlling party of the risk. The principle of symmetry between risk sharing and control force does not mean that the participants with weak control power have no relationship with the risk, but requires the participants with weak control power to cooperate and promote actively without affecting the overall interests of the project. Enter the risk control party's risk management, in this way can realize the PPP project established goal, realizes the win-win situation.

(2) *The principle of symmetry between risk sharing and income:* the gains should be matched with the risks undertaken.

When the controlling party of risk is difficult to determine or the participants have no control power, such as facing economic risk, force majeure risk and so on, risk sharing should follow the principle of symmetry between risk and income. In the standardized market economy environment, the gains should be matched with the risks undertaken. Private sector participation in the PPP project is for profit, so it also has to take risks. For such risks, the private sector measures whether or not the risks will yield corresponding benefits.

(3) *Risk-taking ceiling principle:* Risk-bearing should match the capacity to undertake, and cannot be borne indefinitely by one party.

Risk-bearing should match the capacity to undertake, and cannot be borne indefinitely by one party. Once the risk occurs, it will cause more harm than the bearing capacity of its bearers, which will reduce the enthusiasm of the bearers to manage the risk. In the event of an unexpected situation, the relevant participants shall consult and share the responsibility.

(4) *The principle of taking responsibility for those with low risk cost:* which reflects the win-win concept of PPP project.

The result of risk sharing should minimize the total cost of taking the risk, which reflects the win-win concept of PPP project. The effects of risk sharing should be as follows: to stimulate the production efficiency of the bearers; to follow the clear criterion of sharing; and to minimize the total cost of taking risks.

(5) *Willingness:* to take risks.

Project participants must be willing to take on a risk in order to manage the risk.

5.2 Different Risk Bearers

Based on the principle of risk-sharing [8–12], the previous analysis, as well as a summary of the literature, expert interviews, the following conclusions are drawn:

(1) Most of the risks to be borne by government departments are at the national level and are related to the conduct of government agencies or their officials, mainly expropriation/privatization, concession withdrawal/breach, political opposition/political stability, Supporting infrastructure risk, et al.
(2) The main risks to be borne by the private sector are at the project level, including tax/fee changes, insufficient revenue, higher material costs (private sector), accessibility of financing instruments, improper design, engineering/design quality, site safety, et al.
(3) Risks that should be shared by both parties include force majeure risks, inflation, climate/geological conditions, et al. The commonality of such risks may not be borne by one party alone, and the reasons for the risks may come from both sides.
(4) The risk item in the dispute of the subject of risk bearing should be asked for expert opinion, and determined through the game process such as negotiation and negotiation.

5.3 Risk Sharing Proportion Based on AHP

(1) *Establish evaluation index set, target layer:* the thesis hope to achieve, the reasonable share the risk.

Target layer: the thesis hope to achieve, the reasonable share the risk. Criterion layer: the level of risk sharing index expressed with Bi, n for risk sharing one class index number. A rule layer: for each of the primary index B_i (1, 2 … N), and the son rule layer of *x, y, z* factor (each B_i son rule layer factor is not necessarily the same), namely the secondary indicator of risk sharing. $A = \{\text{reasonable risk sharing}\}$; $B = \{B_1, B_2 \cdots B_n\}$; $B_i = \{B_{i1}, B_{i2} \cdots B_{im}\}$.

Then draws the evaluation matrix B: risk sharing.

$$\begin{matrix} B_{11} B_{12} & \ldots & B_{1\mathrm{x}} \\ \vdots & \ddots & \vdots \\ B_{n1} B_{n2} & \ldots & B_{nm} \end{matrix}$$

Solution layer: k project partners as risk sharing optional "plan": $P_j = \{P_1, P_2 \cdots P_k\}$.

(2) *To construct judgment matrix:* it adopts the pound-for-pound comparison of each index to get the evaluation result after calculation.

In order to avoid the subjective influence brought by less direct scoring, it adopts the pound-for-pound comparison of each index to get the evaluation result after calculation. The result of the pound-for-pound comparison is called the judgment matrix, and the comparison is scored by experts, usually using the 1–9 scale method, that is: 1 point—equally important, 3 points—slightly important, 5 points—important, 7 points—very important, 9 points—absolutely important, 2, 4, 6, 8 points represent the middle value of each grade. Table 2 for the scale method of 1–9.

Calculated by the judgment matrix mentioned in Table 2, each index weight, and consistency check and calculate the maximum eigenvalue lambda Max. $CI = (\lambda_{max} - n)/(n - 1)$. You need to use consistency index RI to modify the CI, in order

Table 2 The scale method

Scale	Definition
1	Indicator I is "as important" as indicator j
3	Index I is "slightly more important" than index j
5	Indicator I is "more important" than indicator j
7	Indicator I is 'very important' over indicator j
9	Indicator I is "absolutely more important" than indicator j
Take the middle value 2/4/6/8	

Table 3 Random consistency index

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.89	1.12	1.26	1.36	1.41	1.46

to avoid random reasons caused the consistency of the deviation, random consistency index RI by look-up Table 3 available:

$CR = CI/RI$, when $CR < 0.1$ think judgment matrix consistency is good, no not logical, or need to modify. In the actual operation process, consistency test can be conducted through Expert Choice software.

(3) *The solution layer weight sum:* the proportion of total each scheme layer is obtained, share ratio of each risk sharing party.

When ownership heavy set through the consistency check, can to aggregation of weighting scheme layer, the proportion of total each scheme layer is obtained, namely the one to share the risk, share ratio of each risk sharing party. Come to the conclusion.

(4) *Case study:* the project company free all the project assets handed over to the government.

The operation mode of Beijing metro line 4 is to divide the project investment and construction tasks into A and B parts according to 7:3. By social investors and government departments to form the PPP project company to complete part B, including the vehicles, signal equipment investment and operation and maintenance of facilities. The government department and the project company to sign the franchise agreement. In project period, the government, the assets formed by its investment in a symbolic price or lease free of charge to the project company, which guarantees its implementation normal return on investment; In the mature stage of the project, the government should participate in the distribution of income and recover part of the investment by adjusting the rent. At the end of the concession period, the project company free all the project assets handed over to the government. Total project investment: 15.3 billion yuan. Franchise period: 30 years. Part A (civil/tunnel): 10.7 billion yuan from Beijing municipal government. Part B (electromechanical/vehicle): the PPP company contributed 4.6 billion yuan. The PPP project to the shareholders of a company: Beijing infrastructure investment co., LTD. (BIIC), Beijing capital group co., LTD. (BCG), the Hong Kong railway co., LTD (MTR).

Firstly, a risk sharing system is established as the “criterion layer” of AHP, which describes which criteria are used to judge the most suitable risk sharing subject. Starting from the principle of risk sharing, this paper sets three indicators: risk control ability, risk bearing ability and risk bearing willingness. The corresponding relationship between the indicators and the principle of risk sharing is shown in Table 4. Risk control ability refers to the ability of the sharing subject to control the risk in advance, that is, can effectively reduce the probability of risk. Risk tolerance measures a participant’s ability to respond to risks after the event, that is, whether it can effectively remedy and respond to reduce the degree of risk damage. The willingness to bear risks expresses the subjective enthusiasm of a participant to bear risks and the degree to which he attaches importance to risks.

Based on the Beijing subway line 4 case trial, the risk of "force majeure" force majeure risks, for the PPP project bears are government departments, the project company. Since the lending Banks or insurance companies need to respond to the irresistible factors, financial institutions are also taken as the main participants to construct the scheme layer.

In conclusion, the AHP level is established as follows: target layer $A = \{\text{risk sharing}\}$; Criterion layer $B = \{\text{risk control ability } B_1, \text{ risk tolerance } B_2, \text{ risk willingness } B_3\}$; Program layer $P = \{P_1, P_2, P_3\} = \{\textit{government department } P_1, \textit{ project company } P_2, \textit{financial institution } P_3\}$.

By issuing questionnaires, experts were invited to compare and score each index in pairs according to the scoring principle of analytic hierarchy process and calculate the weight. A total of 18 valid questionnaires were recovered. The judgment matrix obtained by expert scoring is shown in the Table 4. The score in the table is the average score of 18 experts.

Normalized to the judgment matrix, the operation of each index weight, the results as shown in Table 5.

Based on the data obtained from the questionnaire, the weight of each risk bearing party relative to each indicator was calculated, as shown in the Tables 6, 7 and 8.

By solution of general objective weight of each risk sharing subject aggregation, it is concluded that the inflation risk sharing proportion, as shown in Table 9.

Therefore, for the "force majeure risk" of Beijing metro line 4, the parties share 74.88%. The project company shares 8.92%; Financial institutions share 16.20%.

Table 4 Criterion layer judgment matrix

Rule layer	Risk control	Risk tolerance	Willingness to take risks
Risk control	1.00	3.22	4.18
Risk tolerance	0.31	1.0	2.85
Willingness to take risks	0.24	0.35	1.00

Table 5 Weight of each index in the criterion layer

Rule layer	Risk control	Risk tolerance	Willingness to take risks	Sum	Weight (%)
Risk control	0.65	0.70	0.52	1.87	62.34
Risk tolerance	0.20	0.22	0.35	0.77	25.79
Willingness to take risks	0.15	0.08	0.12	0.36	11.87
Sum	1.00	1.00	1.00	3.00	100.00

Table 6 Weight of each share in the risk control indicators

Risk control	Government department	Project company	Financial institutions	Sum	Weight (%)
Government department	0.79	0.67	0.84	2.31	77.13
Project company	0.10	0.08	0.04	0.21	7.15
Financial institutions	0.11	0.24	0.12	0.47	15.72
Sum	1.00	1.00	1.00	3.00	100.00

Table 7 Weight of each share in the risk tolerance indicators

Risk tolerance	Government department	Project company	Financial institutions	Sum	Weight (%)
Government department	0.74	0.71	0.76	2.21	73.66
Project company	0.12	0.11	0.10	0.33	10.89
Financial institutions	0.14	0.17	0.15	0.46	15.45
Sum	1.00	1.00	1.00	3.00	100.00

Table 8 Weight of each share in the willingness to take risks indicators

Willingness to take risks indicators	Government department	Project company	Financial institutions	Sum	Weight (%)
Government department	0.66	0.66	0.65	1.97	65.72
Project company	0.14	0.14	0.14	0.42	13.90
Financial institutions	0.21	0.20	0.20	0.61	20.38
Sum	1.00	1.00	1.00	3.00	100.00

Table 9 The risk sharing weight aggregation

<table>
<tr><th rowspan="3">Scheme layer</th><th colspan="4">Rule layer</th></tr>
<tr><th>Risk control (%)</th><th>Risk tolerance (%)</th><th>Willingness to take risks (%)</th><th rowspan="2">Share proportion (%)</th></tr>
<tr><th>62.34</th><th>25.79</th><th>11.87</th></tr>
<tr><td>Government department</td><td>77.13</td><td>73.66</td><td>65.72</td><td>74.88</td></tr>
<tr><td>Project company</td><td>7.15</td><td>10.89</td><td>13.90</td><td>8.92</td></tr>
<tr><td>Financial institutions</td><td>15.72</td><td>15.45</td><td>20.38</td><td>16.20</td></tr>
</table>

6 How to Deal with the Investment and Financing Risk of Urban Rail Transit Project in China Under the PPP Model

6.1 Risk Response Actions

(1) Political risks are systemic, borne by the government, against private-sector project companies and lending banks.

Political risks are systemic, borne by the government, against private-sector project companies and lending banks. In the event of political risk, the project company may choose to terminate the contract and claim from the government for loss of capital and expected profits if the contract permits or agrees to suspend the terms of the contract; Lending banks can claim loans from the government or sign new contracts in lieu of the old ones; When the resulting political risk violates the terms of the financing contract, the bank may choose to enter into force of the guarantee/mortgage contract, at which time the bank may lose the principal and interest on the loan it has issued.

(2) Construction risks are borne by the private sector against project companies and contractors.

Construction risks are borne by the private sector against project companies and contractors. In the event of cost overrun, delay in construction period and engineering quality problems, the project company may take measures such as claiming breach of contract damages from the contractor or drawing reserve money from the bank; When problems arise, such as increasing financing costs, the project company may take action to inject new capital or sponsor reserves, or to draw funds from banks. When one of the contractors and the project company is in default, the other party may claim damages for the breach of contract.

(3) Market and return risks are borne by the private sector, which should also be the private sector.

Market and income risks are borne by the private sector, which should also be the private sector. In the event of such a risk, the private sector may require the Government to provide price compensation or extend the franchise period; when other gains are insufficient, the private sector can also increase rents and generate other income.

(4) Financial risks, the project company can take back loans and raise fees or explore other means of income.

In the face of inflation and the risk of interest rate fluctuations, the project company can take back loans and raise fees or explore other means of income, and at the same time, in the event of interest rate fluctuations, the issuing bank will also test pressure on the project company to raise fees and increase revenue to reduce the risk of bad loans. According to the demand price curve, the increase in fees may result in a decrease in market demand, which in turn leads to a decrease in total revenue.

(5) Operational risk are mainly borne by the private sector.

Operational risks are mainly borne by the private sector, which should include the project company and the government. When the project company terminates the contract, the government may claim against the project company; in the event of breach of contract by the operator, the project company may take measures to suspend the operation contract, hire a new operator and claim against the operator; In the event of a labor dispute, the project company may negotiate with the labor force to enforce the labor contract; in the event of technical risk, the project company may claim compensation from the technology provider. The remaining risks present at this time are the same as above.

(6) Force majeure risk are usually not averted by conventional means.

Force majeure risks are usually not averted by conventional means. In response to force majeure, it should be clear that all participants should share and different participants should agree on the definition of "force majeure". Secondly, the transferable force majeure risk should be transferred as far as possible. Non-transferable parts are subject to risk control to reduce risk.

6.2 Combined Investment and Financing Model

How to design the PPP mode of urban rail transit project, how to realize the win-win of government and investor, and the key of implementing PPP mode of rail transit project. Through the use of different PPP operating mode combination, can better avoid and share the risk. The following is a brief analysis of several PPP combination models suitable for rail transit projects.

The urban rail transit project is usually divided into the civil engineering part and the electromechanical part, in which the civil engineering (including the tunnel body, the track, et al.) is about 60–70% of the total investment, and the electromechanical part mainly includes electromechanical equipment such as vehicle, signal and automatic fare collection system, accounting for 40–50%. In the above case, the civil and mechanical parts can be implemented in different modes.

(1) BOT TOD Mod local government grants investors comprehensive development rights to land and stations along the project.

TOD (Transit-Oriented Development, bus-oriented Development): local government grants investors comprehensive development rights to land and stations along the project, and balances investment, construction and operating losses on rail transit projects through land development benefits.

On the basis of the BOT model mentioned above, the BOT TOD model adds the TOD model to the comprehensive development of land along the project, and balances the investment, construction and operation losses of the project through the income of land development. The first phase project of urban rail transit line 2 in Foshan City, which was invested by China Transportation Construction Co., Ltd., adopted the mode of BOT TOD.

(2) Civil BTO electromechanical BOT TOD some local governments and loan banks according to the project requirements have improved.

The government and investors jointly set up a franchised project company. Due to the commonweal characteristics of rail transit projects, it is necessary for the local government to invest in the project companies, and the proportion of equity can be controlled at 20/40%, depending on the local financial situation. The remaining 60% of the investment of the project company is provided by the social investor project company. The requirements for project capital have now been adjusted to 20% of the total investment in accordance with the relevant regulations. But in practice, some local governments and loan banks according to the project requirements have improved.

Civil BTO (Construction-transfer-Operation). The government and the project company sign a franchise contract, stipulating that the civil construction part shall be invested by the project company and handed over to the government after completion, and that the government shall complete the payment of the purchase money year by year within three to five years. At the same time, the government authorized the project company 25–30 years of franchise. The civil construction part of Beijing Metro Line 4 takes the form of local government-owned construction and then leasing to project companies, but only in areas with very high levels of government revenue. Of course, the civil construction part can also be set up by the local government and investors independent project company construction, after completion lease to the concessionaire project company, in the form of rent to withdraw the investment Capital.

Mechanical and electrical BOT (Construction-Operation-transfer): the government signed a franchise contract with the project company, agreed that the mechanical and electrical part of the project company to invest in construction, the government authorized the project company for 30 years of franchise.

TOD (Transit-Oriented Development, bus-oriented Development): increase the TOD model when local finance is insufficient.

(3) Civil BLMT electromechanical BOT model, the civil construction part is leased to the concessionaire project company.

Civil BLMT (Build Lease Major Maintenance Transfer, construction-lease-maintenance-transfer) means that the civil construction part is leased to the concessionaire project company after the investment and completion by the investor and the local government project company, and the electromechanical part BOT is the same as the above.

In this model, the project company reclaims part of the investment in civil construction by rent and is responsible for the maintenance of a certain period of time, which is handed over to the government after the expiration of the period. This model is adopted in the first phase project of urban rail transit line 2 in Xuzhou City, Jiangsu Province.

(4) other combination models, BOOT, BOO, TOT (Transfer-Operate-Transfer, that is transfer-operate-transfer).

There is also BOOT, BOO, TOT (Transfer-Operate-Transfer, that is transfer-operate-transfer), ROT Different PPP models can be designed according to different projects, and risk can be averted, dispersed and transferred through the combination of different models, such as refactoring-operation-handing-over, and the combination of various models can be used to avoid, disperse, and transfer risks according to different projects.

6.3 Conclusion and Deficiency

This paper focuses on the risk management of urban rail transit projects in China under the PPP mode in the following aspects:

(1) *Risk identification and assessment* is adopted to select and supplement the characteristics of the urban rail transit project.

First, the risk checklist method is adopted to select and supplement the characteristics of the urban rail transit project under the PPP mode based on the risk check list of Dr. Ke, summarize and supplement the concept of the work breakdown structure method to identify the 33 risks of the six categories to obtain the risk list. The six risks include system risk, i.e. political, economic, legal, other risks; non-systematic risk, i.e. risk of construction, operational risk.

Secondly, issue questionnaire one, using expert scoring method to analyze the occurrence probability and harm degree of the risk item in the risk list.

The influence degree of each risk item is calculated according to the degree of risk impact proposed by Shen [12].

Finally, the Pareto rule is used to evaluate 24 key risk factors, 4 important risk factors, and 4 secondary risks.

(2) *Risk-sharing:* using the method of literature research, the AHP analytic hierarchy process (AHP).

Firstly, by using the method of literature research, the principle of risk sharing reached consensus in academia is determined: the symmetry of risk sharing and control power; the symmetry of risk and income; the assumption of low cost; the upper limit of risk taking; the willingness to take risks; and so on. And through the literature study, the paper analyzes which risks should be borne by the government and the private sector.

Secondly, the AHP analytic hierarchy process (AHP) is used to determine the specific share proportion of the risk that needs to be shared together. According to the principle of risk sharing, the AHP criterion layer is established: risk control capability, risk tolerance capacity, risk taking willingness, government departments, project companies, and so on. Financial institutions act as program layers.

Finally, taking the "force majeure risk" of Beijing subway line 4 as an example, the second questionnaire is issued, and an example is analyzed and applied by using expert scoring method. The final estimate of force majeure risk for Beijing Metro Line 4 is 74.88% for government departments, 8.92% for project companies and 16.20% for financial institutions.

(3) *Risk response,* the main body of risk differentiation puts forward the coping path of the main risk project.

According to the strategy of risk response, the main body of risk differentiation puts forward the coping path of the main risk project, defines how each project participant carries on the risk response in the PPP project, at the same time proposes to adopt the combined investment and financing mode to transfer the risk and evade the risk.

7 Deficiencies and Prospects

Due to the limited ability to invite experts and the insufficient number of experts that can be invited, the results of the questionnaire survey may not be accurate enough. In addition, the AHP Analytic hierarchy process (AHP) can only score one risk item at a time. If all the risk items that need to be shared are discussed, the workload is huge and it is difficult to realize the questionnaire survey method. Therefore, this paper only selects force majeure risk as an example to demonstrate the steps of AHP method. Because of the limited ability, only the first level is considered in this paper for the criterion layer of the AHP method, and the secondary index of each criterion layer is not refined. In the future, the research process will be carried out in the future. We can continue to refine and improve. The risk checklist method and the literature research method adopted in this paper have some subjective factors in the course of operation, which may lead to insufficient results.

It is hoped that this paper will only play a leading role, so that the research on investment and financing risk management of urban rail transit projects under the PPP mode can arouse the attention of the relevant government departments, relevant enterprises and scholars, and gradually improve and deepen. To promote the benign development of urban rail transit construction in China.

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Evaluation of Value for Money for Urban Rail Transit PPP Projects

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Abstract As an important public infrastructure, Urban Rail Transit has many unfavorable factors such as large capital demand, long construction period, long investment recovery period, etc. The introduction of Public-Private-Partner (PPP) model in the construction and operation process will help offset construction costs. Inadequacies, improve the operation and management level and service quality. The PPP model is regarded as an important means of promoting sustainable economic development under the "new normal economy" and has been vigorously promoted by the government in recent years. However, because it cannot rely entirely on subjective judgments and choices for a certain procurement model, the concept of "Value for Money" is introduced to provide a basis for pre-purchase decisions for Urban Rail Transit PPP projects. The purpose of this paper is to construct a model of Value-for-Money for Urban Rail Transit PPP projects, combine relevant theoretical research, and construct a value evaluation system for Urban Rail Transit PPP items based on the main characteristics of Urban Rail Transit PPP projects.

Keywords Urban Rail Transit · PPP projects · Value for money (VFM)

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1 Introduction

In the process of new urbanization in China, urban rail transit, as an important public infrastructure, shoulders the important responsibility of promoting the development of urban economy. A study shows that by 2020, it is expected that there will be more than 50 urban rail transit systems across the country, with a total planned mileage of 7300 km; At present, the average cost per kilometer of urban rail transit is estimated to be 500–700 million yuan. During the 13th five-year Plan period, the average annual investment in urban rail transit construction will reach 450 billion yuan, and the total investment scale will exceed 2.2 trillion yuan. Compared with ground transportation, the construction of urban rail transit has many unfavorable factors, such as huge capital demand, long construction cycle, long investment recovery period and so on, which makes it particularly difficult to raise capital funds. The introduction of PPP mode in the construction and operation of urban rail transit will help to make up for the shortage of construction funds, improve the level of operation and management and service quality, and promote the optimal allocation of public transport resources.

PPP model is regarded as an important means to adapt to the new urbanization of our country, to resolve the local debt risk and to promote the sustainable development of the economy under the "new normal" of the economy. Especially in recent years, the government has greatly promoted it. As the financing channel of widening urbanization construction, PPP model is beneficial to improve the quality of social investment, alleviate the weakness of investment, and then help to solve the problem of contraction of macro-economic demand. On the other hand, PPP model of promoting cooperation between government and social capital can regulate and innovate relevant cooperation mechanisms, clarify the boundary line between the government and the market, and better abide by the spirit of contract in the market economy. Further promote the market in the allocation of resources play a decisive role. However, because we can't judge and choose a purchase mode by subjective method, we introduce the concept of "value for money" in order to provide the basis for the early purchase decision of PPP project in urban rail transit.

Value for money is defined by the UK Audit Office as "using the best possible means to use available resources to achieve the desired results." In the Ministry of Finance's operational guidelines, it is defined as "the maximum long-term benefit an organization can derive from its available resources". It is beneficial to further standardize the popularization and application of PPP model in our country by evaluating the value for money to judge whether it is desirable or not. It has both theoretical research value and practical application value.

2 Literature Review

Since the 1990's, the value of money (VFM) evaluation has gradually become the focus of the international PPP project research. Scholars in many countries and regions have been in-depth study in order to build and improve the evaluation system of the PPP project, and the most concerned is the quantitative evaluation of the value of money.

Coulson conducted an in-depth study of the UK Treasury's two PFI guidelines (2004 and 2006) to analyze several key factors in value for money quantitative evaluation: including the selection of discount rates, life cycle and residual value [1]. Quantitative treatment of profit margins, tax costs and risks. Shugart enumerates the selection of discount rates in PSC calculations in five countries and regions, such as the United Kingdom, South Africa and Ireland, and discusses how to determine the discount rates based on the quantification and sharing of risks [2]. It is instructive to the quantitative evaluation of the value-for-value of PPP project in our country at present. Shunso put forward that the value-for-value evaluation of PFI model in different industries should be analyzed according to the specific situation, and put forward the shadow PSC pricing method to enhance the scientific and reasonable nature of value-for-money evaluation mode [3].

Wang et al. and Bai combined with the characteristics of China's PPP project, established a value-for-money evaluation model in the process of implementation and application, and conducted an empirical study on the actual cases, and analyzed and summarized the VFM, PSC, LCC and other formulas, a set of calculation conditions applicable to a certain industry, negotiation of core variables and other key content [4, 5]. Shen focused on the method of constructing value-for-money evaluation calculation model, and put forward that the key to the decision-making of urban infrastructure construction PPP project is whether the PPP model can reduce the whole life cycle cost of the project [6]. Cui et al. designed and completed the basic process of value-for-money evaluation of infrastructure PPP project in China on the basis of analyzing the basic operation process of China's infrastructure PPP project, including qualitative evaluation and quantitative evaluation [7].

At present, China's urban rail transit PPP project lacks a practical evaluation system for pre-decision-making. In the course of the project, a comprehensive and scientific value-for-money evaluation framework has not yet been established, more based on expert experience or preliminary research reports. In order to carry on the comprehensive evaluation and the decision-making. The lack of practical evaluation and decision-making methods leads to the current PPP procurement model in urban rail transit is not as scientific and reasonable as other fields. Therefore, in order to solve this kind of scientific problem, it is necessary to evaluate the value-for-money project of urban rail transit through the whole project cycle in an all-round way.

3 Construction of Quantitative Evaluation Model for Value for Money

3.1 Model Design Ideas

In October 2016, the Ministry of Finance pointed out that the PPP and PSC value comparison method was used in the evaluation and analysis of the value-for-money (revised version of the draft for advice). The net present value of the project over the life cycle of the project is compared with that of the public sector and compared with that of the public sector under the same conditions as the input and output performance, and the resulting difference is the result of the VFM. Judging whether the PPP model can reduce the cost of the whole life cycle of the project according to its positive and negative.

First of all, the basic concepts of the relevant concepts of the use of the PPP model in Urban Rail Transit and the evaluation of value for money are explained, and the evaluation system is analyzed from both qualitative and quantitative aspects. Secondly, on the basis of summarizing the basic operational framework of the Urban Rail Transit PPP item, we will focus on the quantitative evaluation model, starting from the two levels of PSC and PPP, focusing on the determination of discounting rate and venture quantification.

3.2 Composition and Calculation Model of PSC Value

We can divide the public sector reference standard PSC value of urban rail transit PPP project into three parts: initial PSC, competition neutral adjustment and risk value. Calculate the net present value of cash flow for each part of the project throughout the life cycle of the project and finally sum it up to get the PSC.

(1) *Calculate initial PSC*

According to the basic definition of the initial PSC and the characteristics of the urban rail transit project, the basic composition of the initial PSC of the urban rail transit PPP project can be concluded: the construction period cost, the operation and maintenance period cost, and the user's third-party income to be deducted.

In calculating the initial PSC, it is necessary to forecast the costs in the whole life cycle of the project, and discount a series of cash flows to the net present value according to the corresponding time point. The formula for calculating the net present value of the initial PSC(NPV_{PSCO}) can be expressed by the following formula.

$$NPV_{PSCO} = \sum_{k=1}^{22} \sum_{j=1}^{n} C_{kj} \times (1+i)^{-j} - \sum_{q=1}^{2} \sum_{j=1}^{n} S_{qj} \times (1+i)^{-j} \tag{1}$$

(2) *Computational competitive neutral adjustment*

Tax is the main component of competition adjustment in PPP project PSC of urban rail transit in China. According to the relevant tax policies and regulations in China, the types of taxes involved in the life cycle of the PPP project of urban rail transit currently include: enterprise income tax, urban maintenance and construction tax, stamp duty, additional education fee, and business tax.

Calculation of the net present value (NPV_{CNA}) of the competitive advantage obtained by the Government from each tax according to the payment time of each tax.

$$NPV_{CNA} = \sum\nolimits_{z=1}^{5} \sum\nolimits_{j=1}^{n} V_{zj} \times (1+i)^{-j} \tag{2}$$

(3) *Calculate the value of risk*

Identifying the risk is the first task to calculate the value of risk. According to the risk allocation framework of the project, the key risk faced by the project is identified and predicted. In this paper, based on the domestic and foreign urban rail transit PPP cases, combined with Zhang and Ning paper proposed China's PPP project life-cycle risk factors [8, 9]. On the basis of identifying quantifiable risks, these risks are quantified to obtain the risk value.

According to the principle of risk sharing, the identified risk will be divided into two parts: transfer risk and retention risk, in order to ensure the clear distribution of transfer risk and retention risk.

$$NPV_{transfer} = \sum\nolimits_{k=1}^{35} \sum\nolimits_{j=1}^{n} R_{kj} \times \xi_k \times (1+i)^{-j} \tag{3}$$

$$NPV_{retention} = \sum\nolimits_{k=1}^{35} \sum\nolimits_{j=1}^{n} R_{kj} \times (1-\xi_k) \times (1+i)^{-j} \tag{4}$$

(4) *Calculate the value of PSC*

After calculating the net present value of initial PSC, competition adjustment, transferring risk and self-retaining risk respectively, the PSC value of urban rail transit PPP project can be obtained by summation.

3.3 Composition and Calculation Model of PPP Value

The PPP value of the project in the preparation phase is also known as the shadow quote PPP value, which includes the government forecast PPP project co-price (i.e. shadow quote government construction operation cost) and the government's own risk cost. The contract price of the PPP project predicted by the government is the estimate of the financial feasible amount of the PPP project by the government, that is, the net present value of the construction operation cost borne by the government departments on the PPP project of urban rail transit, which mainly includes the construction cost of the government. Operation and maintenance costs as well as their other costs.

The essence of government construction cost is equity investment in the whole life cycle of PPP project of urban rail transit; the maintenance cost of government operation and maintenance is reflected as operational subsidy; other government costs are mainly composed of risk taking and supporting investment. Therefore, the shadow quote PPP value (PPP_{sb}) can be obtained by the sum of the net present value of the above four fiscal expenditure responsibilities.

$$\begin{aligned} PPP_{sb} = & Government\ equity\ investment\ expenditure \\ & + Operation\ subsidy + Matching\ investment + NPV_{retention} \end{aligned} \tag{5}$$

The actual quoted PPP value of the urban rail transit PPP project is the net present value of the cost calculated according to the quotation given by the optimal social capital side, plus the risk cost. The only difference between the PPP value of the actual quotation and the PPP value of the shadow quotation is that the contract price of the PPP calculated by the government becomes the actual bid price of the PPP. The actual quoted PPP value often depends more on the operation mode and the return mechanism in the bidding documents, which makes the real quoted PPP value have higher requirements on the income and subsidy of the project.

(1) *Project operating income*

Project revenue can be divided into ticketing revenue and authorized within the scope of advertising and other business income two parts.

Ticket revenue is mainly determined by passenger flow and per capita ticket price. In the bidding process, government departments can carry out ticketing subsidies to make the predicted ticket revenue reach the operating income level expected by the social capital side. Other business income, such as advertising in authorized norm, usually takes the form of user payment, and there is generally no government subsidy. Therefore, when calculating the PPP value of the actual quote, the content paid by the government department can only be counted. In addition, in the UMT PPP item, the government may fund investments in some of the projects to obtain partial cash flows, including by providing leases to social capital parties, as part of the actual bid price.

$$NPV_{Actual\ tender\ price} = \sum\nolimits_{j=1}^{n} \left(Y_j - Z_j\right) \times (1+i)^{-j} \tag{6}$$

(2) *Government investment cost*

When calculating the investment cost of government input into PPP project, the same discount rate should be adopted as the calculation of PSC value.

$$NPV_{Government\ investment\ cost} = \sum\nolimits_{j=1}^{n} (H_j + D_j) \times (1+i)^{-j} \tag{7}$$

(3) *Retained risk*

The retained risk includes the risk borne by the government and part of the risk shared by the government and the social capital side. The residual risk value calculated in the risk adjustment link can be directly used in the calculation.

In summary, the actual quoted PPP value (PPP_{sb}) of urban rail transit PPP project is calculated as follows:

$$\begin{aligned} PPP_{sb} = & \sum_{j=1}^{n} (Y_j + W_j - Z_j) \\ & \times (1+i)^{-j} + \sum\nolimits_{j=1}^{n} (H_j + D_j) \times (1+i)^{-j} + NPV_{retention} \end{aligned} \tag{8}$$

3.4 Determination of Discount Rate

The risk-free interest rate excludes the risk reward, while the discount rate determined by the capital asset pricing model fully reflects the impact of the risk reward. But in the process of quantitative evaluation of value for money in this paper, the impact of risk on cash flow has been quantified and added to the cash flow of the project. In other words, we can look at the cash flow generated by the project as risk-free cash flow. Therefore, it is more suitable to choose risk-free interest rate as value-for-money quantitative evaluation discount rate.

Secondly, in the capital asset pricing model, the systemic risk β coefficient of assets is not well defined. Especially at present, the PPP project of urban rail transit in China lacks a lot of statistical data, and there is no reference range for the value of β coefficient. In order to make the discount rate accurate, risk-free interest rate should be chosen as the discount rate based on the conservative principle.

In summary, the risk-free interest rate is used as the discount rate of the value-for-money quantitative evaluation of urban rail transit, that is, the long-term borrowing rate issued by the government in the same period.

3.5 Quantification and Sharing of Risk

(1) *Quantification of risk consequences*

The other key point of value-for-money quantitative evaluation of urban rail transit is the estimation of risk value, and risk quantification is the process of pricing risk, and the consequences of risk are expressed in the form of cash flow. At present, scenario analysis, probability method and proportion method can be used to quantitatively analyze the risk.

(2) *Principle of risk sharing*

Risk sharing is the allocation of different risks to different subjects, that is, the division of liability for the factors that may affect the income or loss of the project in the future. According to certain principles, the risk of urban rail transit PPP project needs to be allocated reasonably between government departments and social capital parties so as to achieve win-win results, and to improve the efficiency of the project to obtain greater value for money.

According to the main characteristics of urban rail transit (PPP) project and based on the literature review of the field of risk sharing, this paper puts forward four basic principles of risk sharing for PPP project of urban rail transit, which are as follows:

Optimal distribution principle: Some studies have shown that when the risk gradually shifts from low to high, there is an optimal solution to the amount of risk transferred by the government to the social capital, that is, when wind risk is optimally distributed between the government and the social capital, the maximum benefit will be achieved. The lowest cost effect; After deviating from this optimal range, the total cost of risk management will be increased, the overall benefit will be reduced, and the value-for-value of goods will be greatly reduced.

Upper limit principle: During the operation of the PPP project of urban rail transit, there may be a situation where the risks far exceed the forecast range, which makes the risk bearers unable to manage and control the wind risks and lead to the adverse situation such as the surge of project costs. Therefore, in the project agreement, the government and the social capital side should be set the wind risk assumption ceiling, taking into account the financial situation of both sides and risk control ability and other factors, so as to avoid putting one party to the near unlimited risk.

Income equivalence principle: The principle of income equivalence means that the risk to be borne should be matched with the income obtained, and the risk bearer shall have the right to receive a return equivalent to the risk assumed.

Doctrine of liability fixation: The party giving rise to the risk shall bear the corresponding responsibility, and if both parties are liable for the wind risks incurred, the liability shall be shared in accordance with the size of the responsibility.

4 Empirical Research

4.1 Project Overview

The first phase of Xuzhou Metro Line 1 is the backbone line of Xuzhou's rail transit. It is the main artery of the east-west development of Xuzhou's core area, which is the main artery of the east-west development of Xuzhou's core area. The total length of the line is 21.967 km, of which the underground line is 20.996 km long, the elevated line is 0.571 km long, and the open section is 0.4 km long. There are 18 car stations (17 underground stations and 1 viaduct) throughout the entire journey. The average distance between stations is 1.25 km. The project started construction in October 2014 and is scheduled to be put into operation in August 2019.

Xuzhou Metro Line 1 is designed according to the mode of "Capital Investment + Construction General contract" and operated by BLMT (Construction-Lease-maintenance-transfer) mode. The State-owned Assets Supervision and Administration Commission of the Xuzhou Municipal People's Government (hereinafter referred to as "SASAC") is responsible for the specific implementation work.

4.2 Qualitative Evaluation

Based on the contents of the guidelines on value-for-money Evaluation of Government and Social Capital, the value-for-money qualitative evaluation index of PPP project includes 7 basic indexes and corresponding supplementary indexes. According to the results of the "demonstration of value for money" of Xuzhou Urban Rail Transit Line 1 PPP Project, the results of qualitative evaluation of value for money are obtained in this paper.

The total score of PPP model is 88.5, which is obviously higher than the score of 62 points of traditional government procurement mode. It shows that PPP model is better than traditional procurement mode in all aspects, that is, through qualitative evaluation of value-for-money (value-for-money). The risk allocation and management score of life cycle is 81.7%, which shows that the introduction of social capital has greatly improved the identification and distribution of wind insurance, and risk sharing will be more conducive to the operation of the project. The output performance-oriented score is 91.4%, which shows that the introduction of social capital improves the competition degree of the project, promotes its efforts to improve its own service level and output efficiency, and is conducive to innovation in technical management; The reachability score of 86.7% is due to the deep gray capital side generally has more item management experience, as well as stronger financing ability.

4.3 Quantitative Evaluation

According to the Xuzhou Metro Line 1 franchise agreement, the total investment of the project is 16.278 billion yuan, 40% of the capital, 60% of the bank loans. Project bank loans over a 25-year period, the current long-term loan benchmark interest rate of 5.15%, the use of equal principal means of repayment. The project is scheduled to start construction in October 2014, and will be put into trial operation in August, 2019. The project construction company has 25-year franchise (including five-year construction period), so the value-for-money measurement period is 25 years before the construction and operation period. This article chooses the risk-free interest rate as the discount rate. According to the successful issuance of local bonds in Jiangsu Province in July 2014, the 5-year interest rate is 4.06%, the 7-year interest rate is 4.21%, and the 10-year interest rate is 4.29%, because the project cooperation period is 25 years, based on the cost cash flow forecasting theory, The base discount rate is 4.50%.

(1) *Calculation of PSC value*

In this case, since the initial PSC refers to the basic costs required for the construction and operation and maintenance of the Xuzhou Metro Line 1 during the concession period of 25 years when the government adopts the traditional procurement model.

Since there is currently no relevant project database in our country, therefore, the cost calculation and allocation method of urban rail transit proposed by Feng is used in this paper to estimate the amount of each component of the initial PSC [10].

The net present value of each part is calculated according to the discount rate of 4.50%, and the net present value of the construction period is 7.21415 billion yuan, about 7.21 billion yuan.

(a) *Calculate initial PSC value*

In this case, due to the 100-year design life of facilities such as rail transit culverts and underground structures at the site, there is little need for updating, and movable equipment will gradually be stripped from the project construction company during the concession period. Therefore, the assets are not depreciated. Project operation and maintenance costs will mainly include financial costs, operating costs two majority.

Financial cost calculation: according to the project agreement, the project construction company loan about 9.7 billion yuan, the loan term 25 years, the annual interest rate 5.15%, equal principal, repayment period from the completion of the project to operate a total of 20 years. On this basis, the principal and cash flow of each year can be calculated. On the premise of not considering inflation, the net present value of financial expenses can be calculated at a discount rate of 4.50%, which is 9.93 billion yuan.

The unit operating cost is designated as 15.14 yuan/km. Based on the estimated annual number of bus lines of Xuzhou Metro Line 1, combined with the inflation rate estimate, the annual operating costs of line 1 are forecasted. The net present value of the resulting operating cost is 4.35 billion yuan (Table 1).

Therefore, we can obtain the total net present value of operation and maintenance period is 14.28 billion yuan.

(b) *Calculating competitive neutral adjustment*

The implementing party of the project allocates the ticket revenue to the project construction company in a certain proportion, so that the input tax of the construction company is utilized, and because the construction company has a large amount of loan interest deducted before income tax during the franchise period, Reduced the project company's income tax expenditure, thus reducing the financial subsidies. Therefore,

Table 1 Construction period cost composition and estimate amount (Unit: 10,000 Yuan)

Construction period cost	Unit construction basis	Unit construction cost correction value	Construction cost estimate	Net present value of cost
Station project	10,286	12,657	278,032	244,111
Interval engineering	8,362	10,289	226,026	198,450
Track engineering	1,006	1,238	27,192	23,874
Communication and signal engineering	2,325	2,861	62,845	55,178
Feed system	3,853	4,741	104,147	91,441
Ventilation, air conditioning and heating system	1,371	1,687	37,058	32,537
Automatic ticket checking system	909	1,119	24,570	21,572
Escalator elevator	839	1,032	22,678	19,911
Other mechanical and electrical equipment	1,447	1,781	39,113	34,341
Total	30,398	37,404	821,663	721,415

this paper adopts the method of deducting the third-party income deducted from the tax preference to make a fuzzy estimate of the intermediate adjustment item in competition.

(c) *Calculate the value of risk*

According to the PPP project agreement of Xuzhou Metro Line 1, the commercial risks faced by the project design, construction, financing, maintenance, etc., such as labor costs, materials, etc., shall be borne by the social capital or the project construction company. The risks such as design changes and engineering changes in the construction process are attributed to the corresponding risk takers; The government undertakes policies, legal changes, and market risks; Natural disasters and other force majeure Xi'an is shared by the government and social capital.

This paper assumes that risk has five situational consequences: “advantage”, “basic”, “unfavorable”, “worse” and “worst”. The median value of each group is the most estimated value of the risk-bearing cost. By using expert scoring method to estimate the risk probability of cost overrun, the probability of risk occurrence can be estimated under the corresponding situation. Therefore, the quantized table of cost overrun and risk bearing can be obtained by calculation (Table 2).

Table 2 Cost quantification table for construction cost overrun and risk bearing (Unit: 10,000 Yuan)

Risk scenario	Risk consequence	Risk consequence estimate	Risk probability estimation	Value of risk
Advantage	Save more than 5%	−72,142	10%	−7,214.2
Basic	5% savings–5% over-expenditure	0	66%	0
Unfavorable	5–15% over-expenditure	72,142	17%	12,264.14
Worse	15–25% over-expenditure	144,283	6%	8,656.98
Worst	Over-expenditure by 25%	216,425	1%	2,164.25
Total		–	1	15,871.17

Table 3 Valuation table of quantifiable value of risk for construction period (Unit: 10,000 Yuan)

Occurrence stage	Elements of risk	Value of risk	NPV
Design financing phase	Insufficient fund-raising	8,681	7,622
	Item design	9,208	8,085
Project construction stage	Subcontractor default	12,983	11,399
	Construction technical	12,047	10,577
	Engineering overrun	17,595	15,448
	Engineering quality	11,008	9,665
	Construction cost overrun	17,747	15,582
	Acquisition of construction materials and equipment	12,163	10,679
	Organizational supervision responsibility	11,769	10,333
Total		113,201	99,390

Other quantifiable risk values can be calculated based on the value of the risk of cost overruns, and the net present value of the risk is calculated based on the point at which the risk occurs. Since the first beneficiary of the insurance compensation agreed in the PPP cooperation agreement is the government, this will reduce the government's risk to bear the expenditure (Table 3).

The project adopts the "network separation and separation" model to separate the construction period from the operation and maintenance period. Therefore, the infrastructure maintenance and maintenance support situation and risk allocation factors during the operation and maintenance period can be considered with reference, but the maintenance period risk is not considered bear costs. Other quantifiable value of risk can be calculated according to the value method of cost overrun risk, and the net present value of that risk can be calculated according to the point of occurrence of wind insurance. The net present value of Xuzhou line 1 project risk is 0.99 billion

Table 4 Line one company's feasibility gap allowance (Unit: 10,000 Yuan)

Year	*2015*	*2016*	*2017*	*2018*	*2019*
Feasibility gap subsidy	0	19491	38982	58474	77965
Year	*2020*	*2021*	*2022*	*2023*	*2024*
Feasibility gap subsidy	78646	55739	42946	30051	25895
Year	*2025*	*2026*	*2027*	*2028*	*2029*
Feasibility gap subsidy	21527	16920	12876	10192	7165
Year	*2030*	*2031*	*2032*	*2033*	*2034*
Feasibility gap subsidy	3749	2968	2165	1339	760
Year	*2035*	*2036*	*2037*	*2038*	*2039*
Feasibility gap subsidy	760	760	760	760	760
Total subsidy	511651				
Present value	378282				

yuan. It's estimated that the retained risk value is about 198.78 million yuan, and the transfer risk value is about 795.12 million yuan. To sum up, the cumulative sum of PSC value components can get the PSC value of this project is 15.27 billion yuan.

The net present value of that risk can be calculated according to the point of occurrence of wind insurance. The net present value of Xuzhou line 1 project risk is 0.99 billion yuan. It is estimated that the retained risk value is about 198.78 million yuan, and the transfer risk value is about 795.12 million yuan.

To sum up, the cumulative sum of PSC value components can get the PSC value of this project is 15.27 billion yuan.

(2) *Calculation of PPP value*

See Table 4.

According to the concession agreement for Xuzhou Metro Line 1, the rent paid by the implementing agencies for the construction of the project will be set at 1 yuan in nominal rent, while the government's feasibility gap subsidy will refer to the assumptions in the project agreement. The net present value of the government subsidy, that is, the PPP tender price, is 3.78 billion yuan.

It is known that the portion of government investment consists of the annual feasibility gap subsidy and the project capital of 1.578 billion yuan, of which the cost of financing and other expenses is calculated at 24% of the proportion of government funding, taking inflation into account, the net present value of government investment based on a discount rate of 4.50% through excel is 5.02 billion yuan.

In summary, the net present value of PPP value is 9.00 billion yuan.

(3) *PSC-PPP contrast analysis*

From the above calculation results, we can see that $PSC = 15.27$ billion yuan, $PPP_{ab} = 9.00$ billion yuan, so $VFM = PSC - PPP_{ab} = 6.28$ billion yuan >0. It shows that the project is value for money by using the PPP model, that is, through the quantitative evaluation of the value for money, and using the PPP mode procurement will save the government 6.28 billion yuan of fiscal expenditure. According to the calculation results and the influencing factors of the value-for-money evaluation summarized in this paper, it can be concluded that Xuzhou Metro Line 1 has become a demonstration PPP project to realize the value-for-money and two innovation points which are different from those in the past.

Firstly, social capital is introduced in the construction stage and the operation stage respectively. Unlike such super-large cities as Beijing and Shenzhen, Xuzhou City, as a second and third-tier city, has relatively weak financial capacity, and the government needs to find partners who have both the investment capacity and the full credibility of the government's ability to pay and have a strong risk-bearing capacity. Large-scale engineering enterprises have become the first choice. This kind of social capital not only improves the construction and operation efficiency of the project, but also can manage the risk scientifically, greatly reduce the level of risk management, and improve the efficiency and quality of public service.

Secondly, the simple combination of financial conditions. The Xuzhou Metro Line I project introduced the performance appraisal mechanism and the performance protection mechanism, and the expected rate of return on investment was the benchmark interest rate for loans over five years plus 2.45% points. The total contract price of construction is 7% points below the budget of the design plan, which is similar to the traditional bt mode of financial bidding. But in the user pay on the slightly more complicated, but also the government feasibility gap subsidies, facilities rental and ticketing income and other ways. This form of multi-income sources will increase the utilization of assets, offset the project costs to a certain extent, thereby reducing social capital quotations, reducing government payments, and promoting the realization of value for money.

However, it should be noted that due to the limited availability of information, the assumptions made in the estimates of operating costs, ticket revenue estimates, and competition-neutral adjustment estimates are all vague assumptions, which may affect the calculation of the corresponding values and make them subjective color.

5 Conclusion

Government departments should evaluate the value-for-money evaluation of urban rail transit PPP projects when they make purchasing decisions. Based on the summary of the research status of value-for-money evaluation system at home and abroad, this paper summarizes the research status of value-for-money evaluation system at home and abroad. Combined with the main characteristics of urban rail transit project, the basic framework of value-for-money evaluation for PPP project of urban rail transit is improved, and the qualitative evaluation index system and quantitative evaluation model of value-for-value evaluation for PPP item of urban rail transit are put forward.

In order to improve the scientific and accurate evaluation. The main conclusions of this paper are as follows:

(1) *Perfecting the basic Framework of value-for-money Evaluation for PPP Project of Urban Rail Transit.*

The operation process of urban rail transit PPP project is divided into five stages: identification, preparation, procurement, execution and handover. Therefore, the value-for-money evaluation of the project will also be reflected in each stage.

(2) *Putting forward the qualitative evaluation index system and quantitative evaluation model for value-for-money evaluation of PPP project in urban rail transit.*

The public sector reference standard method is selected to compare the value of PSC with the value of LCC, and the conclusion is drawn that whether the project has value for money by using the model of PPP. This method is influenced by many factors such as the selection of discount rate, the quantification and sharing of risk, the adjustment of competitive neutrality and so on.

(3) *Exploring the method of quantifying and sharing the risk of PPP Project in Urban Rail Transit.*

In the quantitative evaluation model of value for money of PPP project in urban rail transit, the calculation of PSC value, shadow quotation PPP value and PPP value of real quotation all include the evaluation of project risk value, therefore, the project risk is identified. Quantification and sharing have become the key to quantitative evaluation of value for money.

However, there are still some shortcomings in the research of this paper. For example, the public sector in the quantitative evaluation model of value for money for urban rail transit PPP project is the reference standard PSC value, the shadow quoted PPP value, The actual quoted PPP value and other indicators are based on the general situation of the urban rail transit PPP items, and some changes may be needed when specific projects are encountered. For example, the empirical research on the value-for-money evaluation of urban rail transit PPP project has some limitations due to the limited data, so the proposed evaluation model of value-for-money still needs to be tested and perfected through a large number of cases.

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Corporate Social Responsibility and Under-Investment Based on Mediating Effect of Analyst Following

Zhiwei Wang and Xiang Xiao

Abstract Based on the data of A-share listed companies in China from 2012 to 2017, this paper empirically examines the impact of corporate social responsibility on under-investment. The results show that, with the improvement of the corporate social responsibility, the degree of under-investment has been significantly reduced. Further studies show that analyst following play a partial mediating role in the process of corporate social responsibility affecting under-investment. The above conclusions confirm that the corporate social responsibility can enhance the investment efficiency while enriching the theory of information intermediation among analysts. The conclusions of this paper can not only motivate corporates to positively shoulder social responsibility and make relevant disclosure, but also encourage government to promote the development of the analyst industry.

Keywords Corporate social responsibility · Analyst following · Under-investment · Mediating effect

1 Introduction

In modern companies, the separation of managerial authority and ownership creates a kind of principal-agent relationship between managers and shareholders. Due to the inconsistency with the shareholders' interests, the manager may abandon the investment project with a positive net present value. Under the circumstance, the investment decisions of the company will not be optimal, so under-investment appears. In addition, the capital market is not perfect, so information asymmetry between stakeholders and managers occurs, which results in enterprises facing financing

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constraints and even giving up worthy projects. In a word, agency conflict and information asymmetry are main reasons for under-investment. However, the appearance of under-investment is not conducive to the development of corporates, which impairs the interests of shareholders. It's necessary for corporates to decrease the degree of under-investment.

In recent years, more and more attention has been paid to corporate social responsibility by society, government and academia. With the rapid development of economy, most corporates don't fulfill social responsibility and make relevant disclosure. In this context, the government has promulgated a series of policies. And more and more scholars are gradually beginning to explore the effect of social responsibility on corporates. Based on stakeholder theory, enterprises ought to shoulder the social responsibility for stakeholders while creating value. The essence of firms is a set of contracts which are signed by different stakeholders. If enterprises want to develop continuously and healthily, they must attach great importance to the relationship with stakeholders. Corporate social responsibility is a concrete manifestation that enterprises are willing to communicate with stakeholders. For companies which face under-investment, corporate social responsibility can reduce information asymmetry, even alleviate financing constraints and reduce agent costs. Furthermore, stakeholder governance, which consists of different stakeholders, is a part of corporate governance. Corporate social responsibility can motivate stakeholders to participate in corporate governance, and encourage them to supervise and restrain managers' agency behavior. However, when enterprises shoulder social responsibility and make relevant disclosure, it is at the price of consuming resources, which is not conducive to value creation activities, and even aggravates the degree of under-investment. It still remains to be seen how corporate social responsibility affect under-investment.

Analysts play a role of information intermediation in the capital market. They use their own expertise to collect basic and industrial information of listed companies, and then provide information about target companies for stakeholders. As the supplement of financial information, corporate social responsibility is one important non-financial information. When fulfilling social responsibility and making relevant disclosure, corporates can provide additional information to the capital market. Whether can corporate social responsibility attract analysts' attention and analysts transmit information of corporate social responsibility to the market?

Based on above analysis, this paper examines the impact of corporate social responsibility on under-investment and even the mediating effect of analyst following. The possible contribution of this paper is to reveal the indirect mechanism of corporate social responsibility influencing under-investment based on the perspective of analyst following. What's more, it can indirectly confirm the theory of information intermediation among analysts.

2 Literature Review

Up to now, there has been scholars studying the relationship between corporate social responsibility and under-investment. Some scholars have found the negative correlation between corporate social responsibility and under-investment, based on different theoretical perspectives, which include stakeholder theory, signaling theory, information asymmetry theory, agency theory. Liu and Wang, taking A-share listed companies in China as research samples, studied the relationship between corporate social responsibility and under-investment [1]. They found corporate social responsibility could improve the investment efficiency of corporates. Further studies showed that corporate social responsibility was negatively related to under-investment, which indicated that corporate social responsibility had a governance effect on under-investment. And corporate social responsibility could regulate the relationship between political connection and inefficient investment to optimize the investment efficiency.

However, under the guidance of resource consumption theory, corporate social responsibility will occupy corporate resources, which may aggravate the under-investment caused by resource constraints, showing that there is not an obvious correlation between corporate social responsibility and under-investment. Zhong and Xu examined the effect of China's mandatory corporate social responsibility disclosure policy on investment efficiency [2]. In 2009, China Securities Regulatory Commission mandated listed firms on growth enterprises market to disclose the information of corporate social responsibility. As an important activity of corporate social responsibility, the relevant information disclosure provides additional information to corporate stakeholders and make benefit to them, but it also has a cost disadvantage. The performance of corporate social responsibility is at the cost of consuming resources, which weakens the activities of value creation. Under the system background, they employed a difference-in-differences research design and found that investment efficiency of the mandated firms improved significantly after disclosure. However, further studies indicated that investment efficiency experienced negligible change in under-investment. So, they inferred that this phenomenon was due to the reason, which was additional financial resources provided by capital suppliers were occupied by the activities of corporate social responsibility.

As the information intermediation in capital market, analysts have the ability to capture information and explain it. The activities of corporate social responsibility provide additional information to the market. Whether can the information have an effect on analyst following? It is necessary to examine the correlation between corporate social responsibility and analyst following. According to existing researches, scholars have found corporate social responsibility is positively related to analyst following. Liu, Liu and Yang using a sample of listed companies in China for the period 2008–2010, introduced short panel data and two-way fixed effects model to test the relationship between the performance of corporate social responsibility and analyst following, and finally found that the performance of corporate social responsibility had a positive impact on analyst following, however such impact was a little lagged. What's more, high level of corporate governance could enhance the positive relationship between the performance of corporate social responsibility and analyst following [3]. Wang and Xu chose the A-share listed companies in China from 2007 to 2014 as samples, and found that social responsibility information was positively related to analyst coverage [4]. Grouping samples test results showed that the properties of heavy pollution industry and low financial transparency could enhance the positive influence significantly. Wang, Yu and An took advantage of the quasi-mandatory disclosure setting in China to investigate whether non-financial information conveyed by corporate social responsibility report improves the information environment of capital market [5]. They found that the disclosure of corporate social responsibility was positively correlated to analyst following. However, such relation only existed in those firms which made relevant disclosure voluntarily. In a word, corporate social responsibility can motivate analyst following. However, the concrete effect of analyst following on firms is still unknown when analysts analyze and interpret the performance of corporate social responsibility.

Throughout the existing researches, scholars draw different conclusions on the relationship between corporate social responsibility and under-investment, which is based on different research perspectives. And corporate social responsibility is positively related to analyst following. Whether analyst following playing a mediating effect on the relationship between corporate social responsibility and under-investment still remains to be seen. Therefore, related conclusions of corporate social responsibility and under-investment and its indirect mechanism are still topics that we need to continue to explore.

3 Research Hypothesis

In perfect capital market, the investment decisions of enterprises conform to the goal of maximizing the corporate value. The market is highly efficient, thus there are no other factors which influence corporate investment decisions. The opportunities which firms facing is the only factor influencing investment. And the scale of investment is positively related to investment opportunities. However, in reality, all kinds of noises will make investment decisions of enterprises deviate and it is difficult to achieve an ideal investment state. The biggest noises causing under-investment in enterprises is information asymmetry and agency conflict. Corporate social responsibility is an effective means to alleviate information asymmetry and reduce agent costs.

First of all, corporate social responsibility helps to promote companies to make active disclosure of information. As an important supplement to financial information, the information of corporate social responsibility can also provide incremental information. Stakeholders can obtain more abundant information related to enterprises, and have a deeper understanding of the business situation, so as to reduce the information asymmetry, which can further restrain the under-investment caused by agent costs and financing constraints.

Secondly, corporate social responsibility propels corporates to shoulder their responsibilities to stakeholders, which mobilizes the enthusiasm of stakeholders to participate in corporate governance, and encourages them to supervise and restrain managers' agency behavior. Accompanied by the mechanism of stakeholder governance, managers are unlikely to make investment decisions that are inconsistent with the goal of maximizing enterprises' value.

Lastly, the performance of corporate social responsibility can release positive signals to the market. On the one hand, fulfilling social responsibility and disclosing relevant information actively do help to establish a responsible social image, thus shaping good reputation of firms. Good images and reputation are scarce intangible resources of firms, which can't be imitated and replaced in a short time. On the other hand, well performance of corporate social responsibility can indirectly convey positive signals of good financial performance and great potential for development to the capital market. These can help firms to reduce the difficulty of obtaining human, financial and material resources from the market, which alleviate the corporate resource constraints, and thus avoid the occurrence of under-investment. Therefore, this paper puts forward the following hypothesis:

H1: There is a negative correlation between corporate social responsibility and under-investment.

The number of analysts tracking a company is actually an equilibrium function of demand and supply for analysts' services [6].

From the perspective of demand, analysts play the role of information transmission in the capital market. When fulfilling social responsibility and making relevant disclosure, corporates will provide incremental information of corporate social responsibility to capital market. Facing so much information about social responsibility, stakeholders will increase the demand of analysts' service to analyze and interpret this information, which trigger more analysts to track it. From the point of view of supply, the performance of corporate social responsibility can expand the effective information sets which are available to analysts. The information is easy to gather and explain. And its cost advantage motivates more and more analyst to cover corporate social responsibility and then release the information to the capital market in the form of research reports, so as to realize the function of information transmission. Under the double promotion of demand and supply, more and more analyst will track the information of social responsibility to analyze it. And the information of corporate social responsibility released by analysts in the form of reports can have a positive impact on firms, alleviating the situation of under-investment caused by financing constraints and agency conflicts. Based on above analysis, the following hypothesis are proposed:

H2: Analyst following play a mediating role in the process of corporate social responsibility affecting under-investment.

4 Empirical Research

4.1 Samples

This paper chose the A-share listed companies in China for the period 2012–2017 as samples. In order to ensure the validity of the research, some samples were eliminated as follows.

Firstly, excluding ST and PT listed companies specifically marked for their poor financial standing and high operating risk.

Then, excluding banking, insurance and other financial industries for using different accounting standards.

Lastly, excluding listed companies with incomplete data during the period of 2012–2017.

After doing all above eliminations, we finally got 4320 observations. All financial data (not including corporate social responsibility) are derived from CSMAR database. As for corporate social responsibility, the relevant data come from Hexun Corporate Social Responsibility Score (http://www.hexun.com). And the following empirical analysis was performed by using stata15.0.

4.2 Variables

This paper mainly uses Richardson's method of calculating inefficient investment to measure under-investment [7]. The scale of investment in firms is influenced by many factors, such as growth potential (*Q*), internal cash flow (*Cf*), return on equity (*Roe*), size (*Size*), life span (*Age*), financial leverage (*Lev*) and so on. So, this paper builds the following model which incorporates those relevant proxy variables [8]. In the model, the symbol of *I* represents the expenditure for the purchase and construction of fixed assets, intangible assets and other long-term assets.

$$\begin{aligned} I_{i,t} = {} & \alpha_0 + \alpha_1 Q_{i,t-1} + \alpha_2 Cf_{i,t-1} + \alpha_3 Age_{i,t-1} + \alpha_4 Lev_{i,t-1} + \alpha_5 Size_{i,t-1} \\ & + \alpha_6 Roe_{i,t-1} + \alpha_7 I_{i,t-1} + \Sigma\, Ind + \Sigma\, Year + \varepsilon \end{aligned}$$

In above model, the negative value of model's residual represents the level of under-investment. This paper takes absolute value for negative residuals and then define them as *UI*. So, the research variables are shown in Table 1.

In above table, the symbol of *UI* is the explained variable, which stands for the degree of under-investment. And the symbol of *CSR* is the explanatory variable, which stands for the performance of corporate social responsibility. The symbol of *Analyst* is the mediating variable, which means analyst following. In addition, other variables are control variables.

Table 1 Variables

Name	Definition
UI	Abs (residuals < 0)
CSR	(Hexun corporate social responsibility score)/100
Analyst	Ln (analysts' number + 1)
Q	Tobin's Q
Cf	Net cash flow from operating activities/total assets
Roe	Net profits/average equity
Size	Ln (total assets)
Lev	Total liabilities/total assets
Age	Listed years
Ind	Ind is 1, when the sample belongs to a specified industry; 0
Year	Year is 1, when the sample belongs to a specified; 0

4.3 Empirical Models

In order to test H1, model (1) is used to estimate the relationship between corporate social responsibility and under-investment:

$$\begin{aligned} UI_{i,t} =& \alpha_0 + \alpha_1 CSR_{i,t} + \alpha_2 Q_{i,t} + \alpha_3 Cf_{i,t} + \alpha_4 Roe_{i,t} \\ &+ \alpha_5 Size_{i,t} + \alpha_6 Lev_{i,t} + \alpha_7 Age_{i,t} + \sum Ind + \sum Year + \varepsilon \end{aligned} \quad (1)$$

In order to test H2, this paper employs causal steps approach to test the mediating effect of analyst following [9, 10]. The approach can be divided into three steps: firstly, testing the correlation between explanatory variable and explained variable, secondly, testing the relationship between explanatory variable and mediating variable; lastly, testing these two variables' joint effect on explained variable. Model (1) is the first step. As for the other two steps, model (2) and (3) are built as following:

$$\begin{aligned} Analyst_{i,t} =& \alpha_0 + \alpha_1 CSR_{i,t} + \alpha_2 Q_{i,t} + \alpha_3 Cf_{i,t} + \alpha_4 Roe_{i,t} \\ &+ \alpha_5 Size_{i,t} + \alpha_6 Lev_{i,t} + \alpha_7 Age_{i,t} + \sum Ind + \sum Year + \varepsilon \end{aligned} \quad (2)$$

$$\begin{aligned} UI_{i,t} =& \alpha_0 + \alpha_1 CSR_{i,t} + \alpha_2 Analyst_{i,t} + \alpha_3 Q_{i,t} + \alpha_4 Cf_{i,t} + \alpha_5 Roe_{i,t} \\ &+ \alpha_6 Size_{i,t} + \alpha_7 Lev_{i,t} + \alpha_8 Age_{i,t} + \sum Ind + \sum Year + \varepsilon \end{aligned} \quad (3)$$

Table 2 Descriptive statistics

Variable	Mean	Std. dev.	Min	Max
UI	0.0202	0.0173	0.0000	0.1715
CSR	0.2514	0.1540	−0.1823	0.8900
Analyst	1.9558	0.8417	0.6931	3.9890
Q	3.0481	15.5397	0.0900	982.9800
Cf	0.0376	0.0782	−0.6702	0.6004
Roe	0.0730	0.1354	−2.2600	3.8800
Size	21.9392	1.0659	15.7294	26.6525
Lev	0.3825	0.2408	0.0100	8.2600
Age	7.3956	5.8057	1.0000	26.0000

5 Empirical Analysis

5.1 Descriptive Statistics

Table 2 shows the results of descriptive statistics. The minimum and maximum value of *UI* is respectively 0, 0.1715, with a mean value of 0.0202, which indicate the degree of under-investment is low. The minimum value of *CSR* is −0.1823, with a maximum value of 0.8900, which reveals that the gap among companies in the performance of corporate social responsibility is large. The mean value of *CSR* is 0.2514, indicating that the overall performance of corporate social responsibility is poor in China. In addition, the mean value of *Analyst* is 1.9558, showing that analysts play an important role in the capital market. The standard deviation of *Q* is 15.5397, which reflect that there are large differences in growth potential among listed firms. The minimum value of *Q* is 0.0900, with a maximum value of 982.9800, which reveals that the gap among listed companies in the growth potential is large. And the mean value of *Roe* is 0.0730, indicating that companies in China have good profitability. In addition, the average in internal cash flow (*Cf*) is .0376, with a mean value of 0.3825 in financial leverage (*Lev*), showing that the operating risk of firms is low.

5.2 Regression Results

Table 3 reports the regression results of the empirical models.

In Table 3, column (1) shows the result of model (1). The coefficient of *CSR* is −0.0051, which is significant at the 1% level. The result indicates that corporate social responsibility is negatively related to under-investment, supporting hypothesis H1. As for control variables, the coefficients of *Q*, *Cf* and *Roe* are both significantly negative, showing that growth potential, internal cash flow and return on equity are able to reduce the degree of under-investment. And the financial leverage

Table 3 Regression results

Variable	UI	Analyst	UI
	(1)	(2)	(3)
CSR	−0.0051***	0.7693***	−0.0046**
	(−2.81)	(9.43)	(−2.48)
Analyst			−0.0007**
			(−2.10)
Q	−0.0030*	0.0021***	−0.0028**
	(−1.96)	(2.71)	(−1.99)
Cf	−0.0052***	0.7565***	−0.0047***
	(−3.38)	(4.94)	(−3.75)
Roe	−0.0024***	0.8242***	−0.0018***
	(−2.79)	(9.19)	(−3.01)
Size	−0.0009***	0.3642***	−0.0007**
	(−3.02)	(26.08)	(−2.03)
Lev	0.0005*	−0.2807***	0.0003**
	(1.85)	(−5.00)	(2.24)
Age	−0.0004***	−0.0311***	−0.0005***
	(−8.49)	(−13.33)	(−8.75)
Constant	0.0542***	−5.5864***	0.0502***
	(7.46)	(−17.17)	(6.68)
Year	Control	Control	Control
Ind	Control	Control	Control
N	4320	4320	4320
F	10.60	21.78	10.53
Adj_R2	0.1510	0.2779	0.1676

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

is positively related to under-investment. It shows that the higher leverage is, the more difficult financing is, which worsens the under-investment. What's more, the adjusted R2 is 15.10%, indicating the model fits better.

Column (2) shows the results of model (2). The coefficient of *CSR* is significantly positive, which indicates there is a positive relationship between corporate social responsibility and analyst following. From the coefficients of control variables, good financial performance and growth potential can attract analyst following. In column (3), the coefficient of *Analyst* means that analyst following is negatively related to under-investment. Based on above basis, the coefficient of *CSR* is still significantly negative at the level of 5% (not 1%), indicating corporate social responsibility has a negative impact on under-investment significantly. The results support hypothesis H2. That is to say that analyst following plays a partial mediating role in the process of corporate social responsibility affecting under-investment.

Table 4 Robustness test

Variable	UI	Analyst	UI
CSR	1.33	1.33	1.41
Analyst			1.36
Q	1.18	1.18	1.18
Cf	1.21	1.21	1.22
Roe	1.25	1.25	1.27
Size	1.87	1.87	2.17
Lev	1.54	1.54	1.55
Age	1.55	1.55	1.62
Mean VIF	3.68	3.68	3.66

5.3 Robustness Tests

In order to ensure the robustness of the results, multi-collinearity tests of each empirical model are carried out respectively. The results are shown in Table 4. The results of each model are reported respectively. Since the maximum value of Variance Inflation Factor (VIF) in each model is less than 10, there is no multi-collinearity in the model.

Measuring errors, missing variables and model specification errors are main causes of heteroscedasticity. For the possible heteroscedasticity problem which exists in this paper, this paper employs White adjustment heteroscedasticity to avoid influencing conclusions. After that, above conclusions are still robust.

What's more, there may be endogenous problem caused by reverse causality between corporate social responsibility and under-investment. That's to say that the degree of under-investment may have an effect on the performance of corporate social responsibility.

So, the variable of corporate social responsibility is delayed by one period in order to avoid this reciprocal effect. Then, this paper uses above models and re-examines the research hypothesis. The results are shown in Table 5. In column (1), the coefficient of *CSR* is −0.0048, which is significant at the level of 1%. It means that the performance of corporate social responsibility can alleviate the degree of under-investment, supporting hypothesis H1. Furthermore, column (2) and (3) report the results of model (2) and (3). In model (2), the coefficient of *CSR* is 0.5770, which is significantly positive at the level of 1%, thus showing that corporate social responsibility is able to attract analyst following. On the basis of model (1) and (2), the coefficients of *CSR* and *Analyst* in model (3) are −0.0042 and −0.0011 respectively, which are both significant. As for the coefficient of *CSR*, |−0.0042| in model (3) is smaller than |−0.0048| in model (1), indicates analyst following has a partial mediating effect on the relationship between corporate social responsibility and under-investment. So, the results are valid.

Table 5 Robustness test

Variable	UI	Analyst	UI
	(1)	(2)	(3)
CSR	−0.0048***	0.5770***	−0.0042**
	(−2.70)	(6.98)	(−2.33)
Analyst			−0.0011***
			(−2.93)
Q	−0.0012*	0.0020***	−0.0010**
	(−1.69)	(2.61)	(2.03)
Cf	−0.0072**	0.6477***	−0.0065*
	(−1.99)	(3.86)	(−1.80)
Roe	−0.0012***	0.8058***	– 0.0003*
	(−3.69)	(8.91)	(−1.74)
Size	−0.0010***	0.3924***	– 0.0005**
	(−2.77)	(24.02)	(−2.15)
Lev	0.0012	– 0.5499***	0.0006**
	(1.58)	(−6.96)	(2.37)
Age	−0.0005***	−0.0293***	−0.0005***
	(−8.60)	(−11.34)	(−9.01)
Constant	0.0545***	−6.0809***	0.0480***
	(6.92)	(−16.53)	(5.86)
Year	Control	Control	Control
Ind	Control	Control	Control
N	4320	4320	4320
F	9.52	18.21	9.53
Adj_R2	0.1620	0.2807	0.1638

***p < 0.01, **p < 0.05, *p < 0.10

6 Conclusions

In this paper, we choose a sample of listed companies in Chinese for the period 2012–2017. This paper begins with the analysis of the relationship between corporate social responsibility and under-investment, and then studies the mediating effect of analyst following on above relationship.

Using the method of mixed ordinary least square regression analysis, this paper confirms that corporate social responsibility is negatively related to under-investment, which means that corporate social responsibility can alleviate the degree of under-investment. Further studies show analyst following has a partial mediating role in the process of corporate social responsibility affecting under-investment, indicating that corporate social responsibility can influence under-investment by attracting analyst following. It also reflects analysts' information transmission, which can improve the efficiency of resource allocation.

The results can provide some reference for firms and regulators. On the one hand, corporate social responsibility has a governance effect, which can motivate enterprises positively shoulder social responsibility and make relevant disclosure. If they want to achieve healthy and continuous development, firms must attach great importance to corporate social responsibility. The performance of corporate social responsibility can alleviate the information asymmetry, lower agent costs and strengthen the ability to attain economic resources, which can finally reduce the degree of under-investment. On the other hand, analysts play a role of information intermediation in the capital market. Analysts have a positive effect on the efficiency of capital market. So, regulators ought to fulfill the responsibility to promote the development of analyst industry, which is conducive to improve the efficiency of resource allocation.

However, this paper exists some limitations. On the one hand, the sample only involves listed companies, not including small and medium sized companies. It's difficult to obtain the data of these companies. On the other hand, this paper only studies the correlation between corporate social responsibility and under-investment and even the mediating effect of analyst following. With the limitation in length, this paper doesn't study the correlation between corporate social responsibility and over-investment and even the mediating effect of analyst following. On the basis of this paper, there will be more and more scholars focus on these limitations and make further studies.

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The Performance of Enterprise M&A Under Various Types of M&A

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Abstract This paper investigates the impact of different types of mergers and acquisitions on company M&A performance. An empirical study is conducted based on the sample data from Chinese listed companies in both 2013–2014. Our research suggests that, on the whole, M&A activity can improve corporate performance, different types of mergers and acquisitions truly have different effects on M&A performance in different periods after M&A, and there is a positive correlation between horizontal mergers and long-term firm performance. Our research findings have implications for companies that choose their M&A types.

Keywords M&A types · M&A performance · Horizontal mergers

1 Introduction

Factors such as scarcity and irreplaceability of resources often drive companies without internal resources to initiate mergers and acquisitions in that they can have access to resources that are not separately present in the market. M&A can help firms to achieve a series of strategic purposes, such as scaling up, optimizing resource allocation, dispersing operational risks and gaining market power. In addition, with Chinese regulators tightening IPO approvals in recent years, companies show particular interest in mergers and acquisitions. Therefore, M&A is getting increasingly active over the years, adding to the value of M&A transactions and diversifying their approaches as well.

Based on the relationship between the industries where the two parties are from, Merger and acquisition activities can be divided into three types, namely horizontal mergers, vertical mergers and concentric or conglomerate mergers. A horizontal

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merger tends to take place when a company intends to scale up its business by taking over its direct competitors in the same industry. A vertical merger is often done with an aim to lower transaction cost by integrating industrial resources into its value chain. Concentric or conglomerate mergers take place when a company aims to venture into other areas of the industry or to diversify into other industries to achieve risk diversification. Different types of mergers have different impacts on the integration process and the realization of the expected synergy of M&A activities.

In Chinese market, however, a great many firms simply pursue expansion or diversification, seeking a merge with no clear motive, and it is no mystery why many mergers end up with poor M&A performance. It is of great importance to understand the function of different M&A types and their impact on performance. However, scholars are divided on the relationship between types of mergers and M&A performance, it remains a topic worth further research. Based on previous research, this article tries to investigate the impact of different types of mergers on the performance of Chinese listed companies, with the control of the average trend of performance in different industries. We hope to shed some light on management's choice of M&A targets and help companies achieve their expected merger and desirable acquisition performance.

2 Theoretical and Hypothesis

2.1 Horizontal Mergers and Corporate Performance

As early as the twentieth century, some scholars, such as Singh [1], Elger and Clark [2], found that relevant mergers play a better role in improving enterprise performance than non-relevant mergers. The same research findings are seen in Chinese academia. Take G. Feng and L. Wu for an example, they conducted an empirical study on the long-term performance of mergers by building a financial indicator system, and found that of the three types horizontal mergers had the best long-term performance [3]. G. Lu used EVA model to measure the performance change in Chinese listed companies, and he found that, for state-owned enterprises, only the horizontal merger could generate value among the three types in the long run [4]. From the perspective of industrial life cycle, C. Fan and J. Yuan analyzed the correlation between various M&A types and the performance of companies M&A in different life cycle, and they believed that, in the growth industry, companies with horizontal mergers have relatively the best performance [5].

Truly, one of the advantages of horizontal mergers is that the scale effect is attainable by increasing production to lower the fixed production cost per unit. Besides, horizontal mergers can also help enterprises enhance its competiveness, gradually enhance industry influence, increase bargaining power, or even reduce the difficulty and cost in financing. What's more, horizontal merger is a good way for companies to obtain intangible assets synergy [6], including management synergy and technical synergy. Management synergy can be achieved when enterprises with strong management ability conduct mergers on enterprises with poor management ability but great potential to generate value, and they can make profit by strengthening resource management. Technical synergy takes place when a large enterprise acquire a small firm with huge technological advantage in the same industry, and they can acquire innovative products or technologies at a lower cost. However, due to the specific nature of the industry, this technical and management synergy can only be carried out between the related industries [7]. Based on the above factors, the paper make the following assumption:

Hypothesis 1: Horizontal mergers can significantly improve corporate performance.

2.2 Vertical Merger and Corporate Performance

With the development of modern capital market, enterprises gradually tend to focus on a certain part of product production, rather than engage in the entire production processes, resulting in close contacts between enterprises and their upstream and downstream industries. This close contact also increases the risks and transaction costs because companies have to spend more money seeking relevant partners in the market, and on negotiation process and supervision of its partners. Opportunism, information asymmetry, and asset specificity are the three main factors that drive up transaction costs [8]. Vertical mergers can help enterprises integrate the industrial chain, generate close links, reduce transaction costs, and thereby improve corporate performance. W. Mao and L. Zhang made a detailed analysis of Mengniu's two vertical mergers and they conclude that vertical merger contributes great to the improvement in company performance by filling the resource gap, promoting industrial chain integration process and ultimately generates a better synergy effects [9]. In addition, with the completion of vertical mergers, the company will scale up, and obtain related benefits as its market power increases. From the perspective of industrial life cycle and enterprise life cycle, Y. Liu finds that vertical mergers can help companies obtain better corporate performance by making full use of their existing market and economic resources, and consolidating their market position [10].

However, after vertical mergers, enterprises are still faced with the risks and costs caused by new upstream and downstream transactions. Moreover, if the acquirer does not have strong operation and management ability, it is more likely to aggravate many management problems, such as difficult coordination among departments. Thus, the second research hypothesis is proposed:

Hypothesis 2: Vertical mergers can improve the performance of mergers and acquisitions.

2.3 Concentric or Conglomerate Mergers and Corporate Performance

First of all, concentric or conglomerate mergers can expand the business scope, diversify income sources, ensure a stable cash flow, thus spread the operational risk. Secondly, for those recession firms, concentric or conglomerate mergers can help them realize the strategic shift into new profit industry and obtain good performance, especially for those companies who intend to enter a higher barrier industry or a highly profitable industry [11]. Yao, Zhao and Wang compared the three M&A types based on the enterprise life cycle, they found that for companies in recession stage, concentric or conglomerate mergers were the best bet [12]. Finally, from the perspective of imperfect external capital market, enterprises could build internal transaction market through non-relevant mergers and acquisitions, so that they could obtain joint insurance effect and lower capital cost, thus achieve better performance than those with other two types [13]. Su used Tobin Q, mark-to-book ratio and excess earnings as indicators to study 926 listed companies. She found that concentric or conglomerate mergers and acquisitions could bring significant positive performance for enterprises [14].

However, concentric or conglomerate mergers also have greater risks. They are more vulnerable to the overconfidence of managers [15]. Because of the great differences in products, technology and sales between two parties of the mergers, managers' understanding of non-related industries are lower than that of related industries, which may complicate their integration. If the manager overestimated their own management capacity, the company would face a greater risk of merger failure. To pursuit personal interests or reputation, managers who work for enterprises with vast surplus capital, may, with a high probability, blindly venture into the industries that are foreign to them. Zhai and Zhang find that there is a significant negative correlation between managers' overconfidence and enterprise performance, especially when enterprises have abundant cash flow [16]. In addition, if companies do not have sufficient surplus resources, the concentric or conglomerate mergers will not only lose the scale effect and its investment in the main business tends to shrink as well, which would dent the overall business performance. By comparing the performance of companies with and without M&A activities in the same time span, Fang and Yan found that both horizontal mergers and vertical mergers could improve enterprise performance, while concentric or conglomerate mergers had a negative effect on enterprise performance [17].

Considering the views of various scholars, this paper draws the third hypothesis:

Hypothesis 3: Concentric or conglomerate mergers can improve the M&A performance.

3 Methodology

3.1 Data Collection

This paper collects sample data from the 2013–2014 annual reports of listed companies for analysis. The research period is from the year before mergers to the second year after mergers. All the relevant data are from CSMAR database and M&A types are divided according to the M&A purpose in WIND's Chinese M&A database. To ensure the validity of the data and the accuracy of the conclusions, the sample data were screened and the screening criteria were as follows:

Excluded in our study are sample data without successful transaction history and complete historical records, sample data of ST and *ST listed companies specifically marked, sample data with the proportion of share conversion less than 10% and the transaction amount accounting for less than 2% of the total assets of the buyer. We only retain the largest transactions of the same firm within a year. With the above eliminations completed, we eventually come up with 110 listed companies.

3.2 Variables

(1) *The explained variable*

The authors use the factor analysis method to build a comprehensive performance mode, through which the paper measures the change of the long-term performance of listed companies in China. In order to comprehensively measure the enterprise performance, this paper selects seven indicators from four aspects: profitability, operational capability, development ability and solvency of the company. The difference between the performance scores of the second year and the year before the merger is measured as the explanatory variable. The selections of indicators are shown in Table 1.

The accuracy of M&A performance evaluation will be affected by the following factor like the different characteristics of each industry, the different impact of changes in related industries and policy. Therefore, this article tries to limit the performance changes in different industries by subtracting the industry average value of financial indicators from 2012 to 2016.

(2) *Explanatory Variable*

This paper chooses the types of merger and acquisition as the explanatory variable, namely horizontal mergers, vertical mergers and mixed mergers.

(3) *Control Variables*

In addition to the types of mergers and acquisitions, other factors also greatly affect corporate performance. Therefore, in order to ensure the reliability and accuracy

Table 1 Factors in comprehensive performance mode

	Financial indicators	Metrics
Profitability	ROA	ROA = (total profits + financial expenses)/average total assets Average total assets = (total ending balance of assets + total beginning balance of assets)/2
	ROE	ROE = net profit/average balance of shareholders' equity Average balance of shareholders' equity = (ending balance of shareholders' equity + beginning balance of shareholders' equity)/2
	Operating margin	Operating margin = operating profit/operating income Quick ratio = (current assets − inventory)/current liabilities
Solvency	Quick ratio	Quick ratio = (current assets − inventory)/current liabilities
	Debt asset ratio	Debt Asset ratio = total liabilities/total assets
Operational capability	Total asset turnover	Total asset turnover = operating income/ending balance of total assets
Development ability	Growth rate of total asssets	Growth rate of total assets = (ending value of assets in the current period − initial value of assets in the current period)/initial value of assets in the current period

of the study, some control variables are added in the process of study: company size, related party transactions, M&A payment method, proportion of independent directors, MOCFOA, year and other dummy variables.

In summary, this article builds the following variable system, as shown in Table 2.

3.3 Models

(1) *Construction of comprehensive performance mode*

This paper, in an attempt to find a comprehensive and objective way to measure the M&A performance, constructs the comprehensive scoring model of enterprise performance in the following four specific periods, namely, one year before the M&A, the year of the M&A, one year after the M&A, and, two years after the M&A respectively, according to the standard steps of factor analysis method.

$$\mathrm{F}_{it} = \beta_{t1} Z_{it,1} + \beta_{t2} Z_{it,2} + \cdots + \beta_{tj} Z_{it,j} \tag{1}$$

Table 2 Variable names

	Variable names	Metrics
Explained variable	ΔPRE_F	It measures the change of the long-term performance by comparing the difference between the scores of the comprehensive performance modes in the second year and the year before the merger
Explanatory variable	MODES	When horizontal mergers occur, MODES takes 1, otherwise it takes 0; When vertical mergers occur, MODES takes 1, otherwise it takes 0
Control variables	RT	When the company has related transaction, RT takes 1, otherwise it takes 0
	METHOD	When the acquirer pays in cash, METHOD takes 1, otherwise it takes 0; When the acquirer pays in stock, METHOD takes 1, otherwise it takes 0
	MOCFOA_PRE	OCFOA = cash flow from operating activities/total assets. Used to control the timing of profitability
	DDR	Proportion of independent directors. DDR = number of independent directors/total number of board members
	SIZE	SIZE = Ln (total assets at the end of the year)
	YEAR	Year is 1 when the sample belongs to a specified year, 0 otherwise

Among them, F_{it} represents the comprehensive score of a certain company in a certain year; β_{tj} represents the ratio of the variance contribution rate/the cumulative variance contribution rate of a certain factor in a certain year; Z_{it} represents the score of a certain factor of a certain enterprise.

Whether the factor analysis method is applicable depends on the statistical criteria. In this paper, SPSS is used for KMO and Bartlett test, and the factor analysis method prove suitable for this study, with its specific procedure omitted.

Based on the ratio of the contribution rate of each factor to the total contribution rate, the comprehensive performance function of enterprise performance in each year is constructed and shown below:

$$\mathrm{F}_{12} = 0.385294\mathrm{F}_{12-1} + 0.24357\mathrm{F}_{12-2} + 0.195263\mathrm{F}_{12-3} + 0.17814\mathrm{F}_{12-4}$$

$$\mathrm{F}_{13} = 0.400088\mathrm{F}_{13-1} + 0.26297\mathrm{F}_{13-2} + 0.175033\mathrm{F}_{13-3} + 0.16165\mathrm{F}_{13-4}$$

$$\mathrm{F}_{14} = 0.395396\mathrm{F}_{14-1} + 0.25327\mathrm{F}_{14-2} + 0.185615\mathrm{F}_{14-3} + 0.16571\mathrm{F}_{14-4}$$

$$\mathrm{F}_{15} = 0.414825\mathrm{F}_{15-1} + 0.38874\mathrm{F}_{15-2} + 0.165092\mathrm{F}_{15-3} + 0.16138\mathrm{F}_{15-4}$$

$$F_{16} = 0.392931F_{16-1} + 0.27247F_{16-2} + 0.170052F_{16-3} + 0.16067F_{16-4}$$

According to the factor score model, the performance comprehensive score of each company in each year is calculated respectively, and the performance changes are measured by the difference between the comprehensive performance score of the current year and that of the previous year.

(2) *Equations*

In order to study the long-term M&A performance of enterprises under different types of M&A, this paper uses the following multiple linear regression analysis model to test the research hypotheses. The model is constructed as follows:

$$\begin{aligned}\Delta PRE_F &= \theta_0 + \theta_1 MODE + \theta_2 METHOD + \theta_3 RT \\ &\quad + \theta_4 MOCFA\_PRE + \theta_5 SIZE + \theta_6 DD\end{aligned} \tag{2}$$

4 Empirical Analysis

4.1 Descriptive Statistics

Table 3 shows the variation tendency in overall sample performance and average performance. It can be seen that M&A activities have a relatively continuous positive effect on enterprise performance, and the promotion has become apparent in the first year of M&A activities, while in the second year, there appears a slight decline, which may suggest both parties need some time to integrate.

The test results in the Table 4 indicate that the three M&A types have different impact on firm performance. First, horizontal mergers have a continuous improvement effect on corporate performance. It shows a dramatic increase in the second year after the merger is completed. Although vertical mergers can significantly improve firm performance in the first year of M&A activities, the average ratios and positive ratios of scores continue to decline over the next two years. A possible explanation might be that companies with vertical mergers can temporarily reducing transaction cost by integrating industry chain, but later on such an effect vanishes with new

Table 3 Overall mean test

	$F_0 - F_{-1}$	$F_1 - F_{-1}$	$F_2 - F_{-1}$	$F_1 - F_0$	$F_2 - F_1$
N	110	110	110	110	110
Mean	0.135***	0.113*	0.182***	0.022	0.087*
SiF.	0.010	0.063	0.005	0.824	0.090

Notes Significance ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

Table 4 Mean test among three M&A types

	$F_0 - F_{-1}$	$F_1 - F_{-1}$	$F_2 - F_{-1}$	$F_1 - F_0$	$F_2 - F_1$
Horizontal mergers	0.099	0.110	0.222**	0.011	0.112***
Vertical mergers	0.243*	0.153	−0.004*	−0.090	−0.157
Concentric or Conglomerate mergers	0.175*	0.089	0.152*	−0.086	0.063

Notes Significance ***p < 0.01; **p < 0.05; *p < 0.10

transactions in the management process, which gives rise to steady decline in performance. The performance of Concentric or Conglomerate M&A shows its trend of rising first, and then falling, which is consistent with findings of most scholars.

4.2 Analysis of Empirical Results

The study conducted a regression analysis of each control variable, and the results are shown in Table 5.

Table 5 Results of multiple regression

	(1)	(2)	(3)
Mode 1	0.231* (−1.924)		
Mode 2		−0.250 (−1.432)	
Mode 3			−0.171 (−1.321)
Method 1	−0.474*** (−3.614)	−0.441*** (−3.358)	−0.458*** (−3.477)
Method 2	−0.257 (−1.150)	−0.200 (−0.871)	−0.245 (−1.075)
Size	−0.137* (−1.789)	−0.100 (−1.443)	−0.135* (−1.684)
MOCFOA_PRE	−0.222 (−1.127)	−0.298 (−1.563)	−0.219 (−1.211)
DDR	−0.811 (−1.111)	−0.719 (−0.965)	−0.749 (−1.048)
RT	−0.146 (−1.133)	-0.140 (−1.093)	−0.142 (−1.096)
Year	YES	YES	YES
_Cons	3.689** (−2.195)	3.020* (−1.962)	3.776** (−2.097)

Notes Significance ***p < 0.01; **p < 0.05; *p < 0.10

The table shows that at the 10% level there is a significant positive correlation between horizontal M&A and long-term performance of enterprises, which verifies our first hypothesis and indicates that horizontal M&A can significantly improve enterprise performance in the long run. A possible explanation is that the companies undertaking horizontal mergers can continue to benefit from economies of scale and synergies and thereby improve their long-term corporate performance. Because both parties in horizontal M&A have similarities in production, technology and marketing channels, proprietary assets between the industry, such as technical capabilities and management capabilities, can be transferred easily, companies can make rapid progress in technology, management, marketing and so on, Therefore, companies with horizontal mergers can gain continuous synergy, cultivate the core competitiveness, and ultimately improve their the long-term performance.

In contrast, there is no significant statistical relationship between occurrence of other two kinds of M&A types and improvement of long-term performance, which means companies could hardly continually benefit from vertical mergers and concentric or conglomerate mergers. The generation of new transaction cost between upstream and downstream may partly explain why companies in vertical mergers have poor performance. Given the limited number of samples, we can not rule out the possibility of the results going extremes and further research is needed. After concentric or conglomerate mergers and acquisitions are completed, managers are often confronted with greater changes in integration since they have entered a new industry they have a thin understand of. Or they might spend lavishly on the expansion process, their investment in the main business will be cut down, which, in the long run, would incur poor performance.

In terms of control variables, firstly, using cash to pay for the mergers has a significant negative effect on the M&A performance. A great demand for cash would cause a burden on the operating cash flow of enterprises, which is a barrier to the desired M&A performance. Secondly, there is a significant negative correlation between the size of acquirer and the performance of M&A under horizontal M&A and concentric or conglomerate M&A. This may be due to the fact that large companies meet greater resistance when it comes to integration because of their complex organizational structure and distinct corporate culture. At the same time, managers from big businesses tend to be overconfident, and overestimate the value of the targets or they have misplaced faith in their ability to integrate business, which may take a toll on the performance of merger, especially the performance of concentric or conglomerate M&A.

5 Conclusion and Revelation

5.1 Conclusion

By adopting factor analysis method and establishing multiple regression models, we conduct empirical research on the M&A performance of 110 listed companies with horizontal mergers, vertical mergers and concentric or conglomerate mergers from 2013 to 2014, and draws the following conclusions about the impact of these three different M&A types on enterprises performance:

First, although the impact of M&A activity on firm performance is slightly fluctuating, overall, M&A activity can continue to improve corporate performance.

Second, in the long run, horizontal mergers and acquisitions have a significant positive effect on enterprise performance. In the next few years since merger and acquisition, the improvement of performance continues to rise steadily.

Third, although vertical mergers and concentric or conglomerate mergers show better performance improvement than horizontal mergers in the short term, the formers are not sustainable. In the long run, vertical mergers and concentric or conglomerate mergers have no significant impact on enterprise performance.

Fourth, there is a significant negative correlation between cash payment method and long-term enterprises performance in all three types. The company size is only negatively correlated with the performance of horizontal mergers.

5.2 Revelation

First, companies should make a reasonable and effective analysis of the feasibility of M&A before the merger, and carefully weigh their remaining and scarce resources and their strategic objectives before they select the M&A types to achieve their desired expected merger and acquisition performance.

Second, horizontal mergers and acquisitions can rapidly and effectively expand the scale of enterprises and achieve continuous synergy, which has a significant effect on the improvement of long-term company performance. However, companies are encouraged not to pursue an undue scaling up through horizontal merges.

Third, for those enterprises that hope to lower transaction costs through vertical mergers and acquisitions, they should carefully consider whether vertical M&A activity is their best choice. However, vertical mergers is worth considering if the company has reached its corporate maturity, a time of strong competitiveness.

Finally, for companies that expect to achieve higher performance through diversification, they should reconsider their own strengths and strategic goals in order to avoid following the trend of concentric or conglomerate mergers blindly and minimize integration failure caused by the lack of understanding of non-related industries.

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Energy Performance Contract Financing Mode Based on Network Joint Guarantee

Luyao Feng, Jingjuan Guo, and Ying Li

Abstract The difficulty in financing small and medium-sized energy service company is one of the obstacles to the smooth development of energy performance contract. Based on the characteristics of energy performance contract, this paper introduces the network joint guarantee loan, demonstrates the advantages of this mode in the field of energy performance contract in China at the present stage, and analyzes the income distribution of energy service companies under the network joint guarantee loan through the modified Shapley value algorithm. It is shown that this mode not only improves the income of energy service companies, but also transforms the contribution and risk taken by companies in their cooperation into income. Therefore, this financing mode is one of the favorable modes for energy service companies to choose.

Keywords Energy performance contract · Network joint guarantee loan · Financing mode · Shapley value algorithm

1 Introduction

Energy performance contract (EPC), a market-oriented energy saving transformation mode in which energy service companies (ESCO) sign energy management contracts with clients, provides energy diagnosis, transformation, management and other services, which enables the clients to gain profits by sharing energy efficiency.

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Since 1998, the effectiveness and flexibility of China's EPC in energy conservation and emission reduction have been widely recognized [1]. China's EPC project investment reached 117.1 billion RMB in 2018, an increase of 5.2% that of last year, forming an annual energy saving capacity of 39.3 million tons of standard coal, and an annual emission reduction of CO_2 106.5 million tons. Compared with the "12th Five-Year Plan" period, the annual investment increased by 57.79%, the annual energy saving capacity increased by 58.46%, and the annual emission reduced by CO_2 71.77%, achieving remarkable results in energy saving and emission reduction [2]. It's clear that EPC mode has become a major contributor that cannot be ignored in the development of China's energy conservation industry. During the "13th Five-Year Plan" period, China will achieve energy saving of 780 million tons of standard coal, and comprehensively promote the contract energy management mode. Therefore, when we are faced with a more severe energy saving situation and a quantified target responsibility assessment mechanism, EPC is still an important way for China to promote energy conservation, emission reduction and energy efficiency.

Although EPC mode has great potential in China, there are still many obstacles in its implementation. One of the biggest barriers to development is financing. Vine [3] thinks that the main causes of EPC financing difficulties are the information asymmetry between ESCOs and financial institutions, and the asset-light nature of ESCOs. Many scholars have proposed solutions to this problem. For example, Zhang [4] and Zhu [5] put forward the loan guarantee mode, which can effectively alleviate the financing difficulty of EPC by reducing the risks taken by banks. Yu and He [6], Wen and Cao [7] and Zhou et al. [8] maintain that to solve the financing problems of EPC, the financing mode should be innovated. They put forward the concept that "Financing equipment is financing": combining financial leasing and EPC. It can solve the problem of equipment leasing, thus alleviating the financing problems of EPC indirectly so as to achieve win-win; on the other hand, Zhu and Yu [9] explore a financing mode of separating EPC project credit from company credit through asset securitization. Apart from the above views, other financing modes like green bonds, future earnings pledge, and the combination of BOT mode were also put forward.

In summary, improving the comprehensive strength of ESCOs and enhancing the economics of project and the accuracy of energy efficiency evaluation are the key ways for ESCOs to obtain direct financing. Likewise, establishing an information transmission mechanism between financial institutions and ESCOs, innovating the guarantee mechanism and reducing investment and financing risks are the key ways for financial institutions to support the development of EPC. By combining the above ways, this paper proposes a financing mode suitable for China's current small and medium-sized ESCOs. Through an analysis of financing effects, this paper explores the feasibility of financing mode, and provides some reference for alleviating the financing problems of small and medium-sized ESCOs and expanding EPC financing channels.

2 Establishing EPC Financing Mode Based on Network Joint Guarantee

According to the above analysis, the implementation of China's EPC mode has not yet reached the stage of large-scale development. According to the statistics of China's energy conservation service industry association during the "12th Five-Year Plan" period, China's EPC project investment accounted for 75% of the less than 10 million yuan investment. The highest investment amount is 2–5 million yuan, and ESCO's average number of employees is between 11 and 40 people. Thus, ESCOs corporate scale and EPC project scale are difficult to form scale economy. Although many scholars have proposed innovative financing methods, there are still many problems in implementation. Therefore, it is necessary to propose a financing method that is more in line with actual needs for the specific stage of EPC development.

In line with the trend of the Internet era, network joint guarantee loan, as a financing method to solve the financing difficulties of small and medium-sized asset-light companies and reduce the risk of bank loans, has been widely recognized in recent years. In this regard, Pan and Fan [10] think that network joint guarantee is a financial innovation product with e-commerce as a platform with a new risk management concept and risk avoidance mechanism. In recent years, this mode has improved the traditional financing mode and has received a lot of attention. Its unique features are as follows: 1. Unsecured. Zhao and He [11] and Xie and Li [12] report that the network joint guarantee mode regards the joint venture as a whole, forming an overall reputation mechanism, and then integrating the credit penalty mechanism and the social guarantee mechanism through three mechanisms. The combination of the above loan processes promote the effective implementation of the contract. 2. Low interest. The loan interest rate of this mode is generally between 6 and 9%, which is much lower than the private lending rate. 3. High security. While solving the problem of financing loans for asset- light companies, this mode also reduces the risks borne by banks. Li and Li [13] and Pan et al. [14] accept that when network bonded loans can increase the cost of default for ESCOs, they can also improve the internal and external repayment efficiency of ESCOs, thus reducing the risks borne by banks. And Ma et al. [15] and Zhou et al. [16] think that this mode can effectively alleviate the losses caused by information asymmetry in financing. In view of the above advantages, network joint guarantee loan mode is more in line with the characteristics of China's current EPC mode development, and can solve EPC financing difficulties more systematically.

2.1 The Operation Mode of EPC Network Joint Guarantee Financing Mode

At this stage, the general network mode mainly involves three main parts: the joint venture composed of small and medium-sized ESCOs, the bank and the investment and financing network platform built by the government departments. Due to the

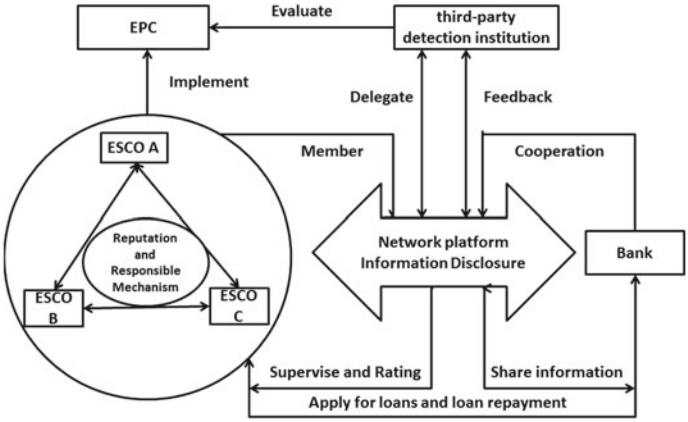

Fig. 1 Schematic diagram of EPC network joint guarantee financing mode

professional and technical characteristics of the EPC project, third-party professional testing can be added. The specific operation mode is shown in Fig. 1. The joint venture has complementary advantages. The network platform acts as a bridge and information center. It is responsible for the overall rating of the joint venture. The EPC project is evaluated by a third-party testing agency to ensure the economics of the joint venture's overall credit and EPC projects. Information sharing between the network platform and the bank can screen high-quality customers and high-reliability projects for banks, and then file and disclose ESCOs with bad bank loan records.

In real life, banks often regard the financing projects of ESCOs as high-risk projects, for China has no relevant systems and legal constraints. As a result, banks cannot fully trust the information obtained through such "weak relations" [17]. Hence, ESCOs that use network joint guarantee loans can apply to join the joint venture and become members of the investment and financing network platform built by the government departments. On this platform, ESCOs' businesses can share information with banks, enhance their connections, and strengthen their understanding of the industry. Over time, a specific information dissemination network will be formed. In this particular network, each participant gradually trusts each other, and begins to cooperate on the basis of the rules of the network platform. The network platform can effectively clear the channel for information transmission between the participants [18].

The operation process of the ESCOs financing mode under the network joint guarantee (as shown in Fig. 2) includes: 1. Setting up the joint venture. Three or more interested members choose each other to form a joint venture. 2. Examining the members of the joint venture. Members can understand the operating conditions, technical level, solvency and development prospects of other interested members through field visits and interviews to ensure the quality of the partners. 3. Calculating the loan amount and sign the cooperation agreement. Considering the profitability

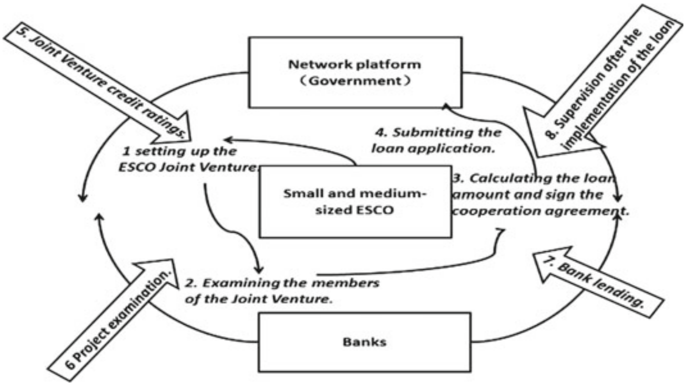

Fig. 2 EPC network warranty financing mode operation process

of each member's participation in the EPC project and the solvency of ESCOs, banks jointly negotiate and determine the loan amount of each member, and sign the member cooperation agreement. 4. Submitting the loan application. The joint venture must submit a loan application on the network platform. 5. Joint venture credit ratings. The network platform reviews the business level, business capability, profitability, solvency and credit of the joint venture through customer resources and credit databases, and also focuses on the default situation of each company. Finally, the comprehensive evaluation of the joint venture assessment is combined with various indicators. 6. Project examinations. For the joint venture through credit rating, the network platform entrusts a professional third-party testing agency to evaluate the feasibility of the project. 7. Bank lending. The joint venture of credit rating and project examinations through the network platform can obtain the corresponding loan according to the loan application amount submitted by itself. 8. Supervision after the implementation of the loan. Each member of the joint venture supervises each other's use of funds and the repayment of loans due, ensuring that each ESCO fulfills its repayment obligations on time, and exposes its breach of contract to the ESCOs that has breached the contract.

2.2 Characteristics and Application Advantages of EPC Network Joint Guarantee Financing Mode

(1) *Competitive advantage of the synergy of joint venture*

According to the lemon market theory, many high-quality projects become a "lemon" in the lending market, which is unable to obtain financing. Due to the asymmetry of information, banks often regard small and medium-sized ESCOs projects as high-risk projects. However, the income of the creditors can be guaranteed not to be damaged, after the guarantee mechanism is added. The survey shows that the repayment efficiency can be increased to 90–98% in the network joint guarantee loan [19]. The formation of the joint venture is based on the mutual trust between members, and then through the combination of self-selection, joint responsibility and horizontal supervision. This "combination" mode can give full play to the technical and management advantages of each company and complement each other's advantages. This not only improves the comprehensive strength and technical level of the joint venture, but also enhances the credibility of the group, which reduces the bank's huge operating costs and information costs for choosing high-quality ESCOs, which achieves the economies of scale of "1 + 1 > 2" in the loan, and forms a common competitive advantage.

(2) *Alleviation of information asymmetry through information transmission on the network platform*

In 2006, Muhammad Yunus, a Nobel Prize winner, created a small joint guarantee loan project that helped hundreds of millions of people out of poverty. The project reduced information asymmetry by establishing a system of "mutual support group + loan center", "contact + regular meeting", "lender + depositor + shareholder". Therefore, establishing an open communication mechanism is very important for project financing. According to the statistics from 2018, in EPC for energy-saving renovation of buildings and public facilities, although the percentage of investment in all EPC projects is 33%, the number of buildings accounts for is 57%. Public institutions are the main participators in carrying out building energy-saving EPC projects. The establishment of a network platform under the leadership of the government can reflect the government's support for energy conservation, strengthen the credibility of the platform, and facilitate the promotion of public institutions EPC projects. For example, the network platform of the Shenzhen Municipal Administration Bureau and the network platform of the Planning and Development Center of the Ministry of Education are all typical network platforms for promoting EPC projects. First, establish an ESCOs corporate network file, collect information from ESCOs member companies through the platform, establish a network credit system, and bundle company credit with corporate personal credit. Then, establish a credit information sharing mechanism. When the joint venture applies for a loan, the platform will evaluate the credit of the joint venture, disclose ESCOs' information to cooperative banks, alleviate information asymmetry between banks and small and medium-sized ESCOs, and effectively contain the confusion caused by information asymmetry [20].

(3) *The potential of network joint guarantee to solve the problem of insufficient guarantee in the loan*

The company mortgage is essentially mortgaged to the bank. There is no physical collateral in the process of network joint guarantee. Pan and Tong [21] report that network joint guarantee is an innovative financing method based on traditional group loans. It uses network technology to increase the network information disclosure mechanism. The synergy of the mechanisms expands the credit efficiency of the joint venture.

(a) *Implicative duty mechanism.* The ESCOs are often listed as high-risk projects. Due to information asymmetry, banks cannot fully confirm the repayment ability of them. However, the bank can reduce the cost of choice through network joint guarantee. During the use of funds, members will communicate, supervise, encourage and restrain each other, thereby increasing the repayment rate and reducing the risk of bad debts [22].
(b) *Reputation mechanism.* At the present stage, especially for an individual ESCO, it is difficult to sign a credit contract with the bank. However, the platform can promote the effective implementation of credit contracts through the overall reputation mechanism, credit penalty mechanism and social guarantee mechanism established within the group, after forming a joint venture. The overall reputation can be increased by the number of participants and transactions to form a larger economies of scale. Besides, the credit penalty mechanism will have a serious impact on its future development, when any company loses its trust [23].
(c) *Network information release mechanism.* This mechanism is the biggest innovation of the network-linked financing mode. It uses the Internet to achieve information sharing between banks and ESCOs. Under the dynamic monitoring of the network platform, once the members of the joint venture fail to believe, the platform will disclose them. Due to the efficient dissemination of information, internal and external governance and high transparency of information will amplify the social punishment of defaulting companies [24], making the cost of default of companies far more than the cost of loans.

(4) *Introduction of third-party testing agency to improve project economics and energy efficiency evaluation*

During implementation of the EPC project, the amount of energy savings is not only the focus of participators, but also the source of benefits. A third-party professional testing agency can provide professional services such as energy audit, energy monitoring, energy-saving diagnosis and energy-saving assessment for the whole process of the project. Network joint guarantee can enhance the accuracy of energy efficiency evaluation, provide guarantees for obtaining loans, and ensure repayment of loans. All of the above will facilitate bank financial risks and ensure the smooth implementation of EPC contracts.

(5) *Reducing credit risk of banks though the synergy of multiple mechanisms*

First, the credit risk of the joint venture has been reduced in essence, because the overall size of the joint venture has increased and its ability to withstand external risks has increased. Secondly, the behavioral motive of each company in the joint venture is to achieve income sharing rather than income gambling. The members are not risk-driven but will share risks. The synergy of a series of mechanisms will reduce the bank credit risk, such as network transaction credit system, the individual unlimited joint responsibility mechanism, the whole process review mechanism, and the post-loan network information disclosure mechanism.

3 ESCOs Income Analysis Under EPC Network Joint Guarantee Financing Mode

According to the above analysis, the network joint guarantee financing mode can effectively solve the specific problems of the EPC financing difficulties proposed above. However, ensuring the benefit of ESCOs is the internal driving force for the real implementation of this mode. Shapley value algorithm is a cooperative gamble mode that distributes income according to the contribution of each company in the joint venture. It can analyze the change of income distribution of ESCOs under the EPC network joint guarantee financing mode. Therefore, this paper demonstrates the feasible of network joint guarantee mode.

3.1 Overview Shapley Value After Risk-Sharing Correction Factor

Combined with the above analysis results, the income distribution mode of this paper is based on the following hypothesis: (1) As each ESCO that cooperates is rational, the rational strategy is used to select the optimal strategy. And the ultimate goal of ESCO is to maximize its own income. (2) ESCOs' cooperation under the network joint guarantee credit mode can generate more benefits than non-cooperation; (3) The benefits obtained by the entire joint venture will not decrease, when the number of cooperative ESCOs increases.

There will be different modes of cooperation, resulting in different benefits, when ESCOs form a joint venture. Let set $I = \{1, 2, \ldots, n\}$, for any subset s of I (representing different cooperation modes between ESCOs), $v(s)$ denotes the overall benefit when the cooperation mode is s. The constraints it satisfies are:

$$v \geq 0, \text{ and } v(\phi) = 0(\phi \text{ sign empty set}) \tag{1}$$

$$v(s_1 \cup s_2) \geq v(s_1) + v(s_2), s_1 \cap s_2 = \phi(s_1, s_2 \subseteq I) \tag{2}$$

$v(I)$ represents the maximum benefit of all ESCOs' cooperation, x_i represents that i members should receive from the maximum benefit of cooperation $v(I)$, and $v(i)$ represents the i earn income when it does not cooperate with other ESCOs. On the basis of I mode, the cooperative income is represented by $x = (x_1, x_2, \ldots, x_n)$ so:

$$\sum_{i=1}^{n} x_i = v(I), i = 1, 2, \ldots, n, \tag{3}$$

$$x_i \geq v(i), i = 1, 2, \ldots, n. \tag{4}$$

The Shapley value represents the income earned by each ESCO under the cooperation I and is recorded as: $\Phi(v) = (\varphi_1(v), \varphi_2(v), \ldots, \varphi_n(v))$, where $\varphi_i(v)$ represents the distribution of income from the member i under cooperation I, so:

$$\varphi_i(v) = \sum\nolimits_{s \subset s_i} w(|s|)[v(s) - v(s \backslash i)], i = 1, 2, \ldots, n, \tag{5}$$

$$w(|s|) = \frac{(n - |s|)!(|s| - 1)!}{n!}, \tag{6}$$

S_i is all subsets of member I in set I, |s| is the number of elements in subset s, n is the number of elements in set I, $w(|s|)$ can be regarded as a weighting factor, $v(s)$ is the benefit of the subset s, and $v(s \backslash i)$ is the benefit that can be obtained after the company i is removed from the subset s.

In the standard Shapley value algorithm, each company's risk is equal; that is, $R = \frac{1}{n}$. In fact, the risk cannot be shared. In general, due to the operation of multiple mechanisms under the network joint guarantee mode, each ESCO faces less risk than the non-cooperation. However, each ESCO will be faced with different risks due to different EPC projects, clients, and changes in external markets and natural conditions. These risks will also affect the distribution of income in cooperation. Therefore, it is necessary to use the risk sharing correction coefficient to correct the Shapley value. The commonly used correction method uses the ANP method, the AHP method, the fuzzy comprehensive evaluation method, etc. They are used to calculate the risks assumed by each company in the joint cooperation process, and quantifies it as risk-based. The income distribution weight indicator corrects the Shapley value.

The correction of Shapley value algorithm is as follows: the overall benefit of the cooperative joint venture is $v(I)$. In the ideal situation, considering the risk equalization factor, the income distribution obtained by a single company is. Under actual circumstances, the income distributed by a single company is $v(i)$. The actual risk assumed is R_i, $i = 1, 2, \ldots, n$. The difference between R_i and the average risk is:

$$\Delta R_i = R_i - \frac{1}{n}, \tag{7}$$

$$\sum_{i=1}^{n} R_i = 1, \sum_{i=1}^{n} \Delta R_i = 0, \tag{8}$$

Therefore, the real gains from the company are:

$$v(i)' = v(i) + \Delta v(i), \tag{9}$$

$$\Delta v(i) = v(I) \times \Delta R_i, \tag{10}$$

$\Delta v(i)$ represents the difference between the actual situation and the ideal income.

In general, the risks assumed are directly proportional to the income earned. Therefore, $\Delta R_i \geq 0$ represents the company actually bears more risks than ideal, so it should get more income. Then the income at this time is

$$v(i)' = \mathrm{v}(i) + \Delta v(i) = v(i) + v(1) \times |\Delta R_i|, \tag{11}$$

when $\Delta R_i \leq 0$, the income is

$$v(i)' = \mathrm{v}(i) + \Delta v(i) = v(i) - v(1) \times |\Delta R_i|, \tag{12}$$

Therefore,

$$\sum_{i=1}^{n} v(i)' = \sum_{i=1}^{n} v(i) + v(I) \times \sum_{i=1}^{n} \Delta R_i = \sum_{i=1}^{n} v(i) = v(I). \tag{13}$$

3.2 ESCOs Income Analysis Based on Shapley Value Algorithm

Suppose there are three ESCOs, A, B, and C. Combined with the above assumptions, assuming that the three ESCOs do not form joint venture and independently borrow from the bank, each ESCO will make a profit of 100 thousand yuan. Assuming that A and B form a joint venture to apply for bank loans, the joint venture can make a total profit of 450 thousand yuan. A and C form a joint venture, which can make a profit of 300 thousand yuan. B and C form a joint venture, which can make a profit of 200 thousand yuan. A, B, and C form a joint venture, which will result in a total profit of 600 thousand yuan. If the income of the three cooperatives are equally divided, each ESCO will receive 200 thousand yuan. However, it is difficult to mobilize enthusiasm in the sharing method, and A and B believe that 200 thousand yuan is less than the combined income of the two companies A and B, so they may not want to join the joint venture. The Shapley value algorithm is used below to recalculate the income distribution in the cooperation.

(1) *Estimation of Shapley values for each ESCO*

From the Table 1 and Shapley value calculation formula, the Shapley value of the ESCO A can be obtained as follows:

$$\begin{aligned}\varphi_A(x) &= \sum\nolimits_{A\subset s} W(|S|)[v(S) - v(S\backslash A)] \\ &\frac{v(A)}{3} + \frac{[v(A, B) - v(B)]}{6}\end{aligned}$$

$$
\begin{aligned}
&+\frac{[v(A,C)-v(C)]}{6}\frac{[v(A,B,C)-v(B,C)]}{3}\\
&=\frac{10}{3}+\frac{35}{6}+\frac{10}{3}+\frac{40}{3}\\
&=25.83\ \text{thousand yuan}
\end{aligned}
$$

Similarly, the Shapley values algorithm of energy-saving service companies B and C are:

$$
\begin{aligned}
\varphi_B(x) &= \sum\nolimits_{B\subset s} W(|S|)[v(S)-v(S\backslash B)]\\
&\frac{v(B)}{3}+\frac{[v(A,B)-v(A)]}{6}\\
&+\frac{[v(B,C)-v(C)]}{6}\frac{[v(A,B,C)-v(A,C)]}{3}\\
&=\frac{10}{3}+\frac{35}{6}+\frac{10}{6}+\frac{30}{3}\\
&=20.83\ \text{thousand yuan}
\end{aligned}
$$

and

$$
\begin{aligned}
\varphi_C(x) &= \sum\nolimits_{B\subset s} W(|S|)[v(S)-v(S\backslash C)]\\
&\frac{v(C)}{3}+\frac{[v(A,C)-v(A)]}{6}\\
&+\frac{[v(B,C)-v(B)]}{6}\frac{[v(A,B,C)-v(A,B)]}{3}\\
&=\frac{10}{3}+\frac{10}{3}+\frac{5}{3}+5\\
&=13.33\ \text{thousand yuan}
\end{aligned}
$$

Table 1 Energy-saving service Company A income distribution table

Elements in S	ESCO A	ESCO A, B	ESCO A, C	ESCO A, B, C
v(S)	v(A) = 10	v(A, B) = 45	v(A, C) = 30	v(A, B, C) = 60
v(S\A)	0	v(B) = 10	v(C) = 10	v(B, C) = 20
v(S) − v(S\A)	v(A) = 10	v(A, B) − v(B) = 35	v(A, C) − v(C) = 20	v(A, B, C) − v(B, C) = 40
|S|	1	2	2	3
W(|S|)	1/3	1/6	1/6	1/3
W(|S|)[v(S) − v(S\A)]	v(A)/3 = 10/3	[v(A, B) − v(B)]/6 = 35/6	[v(A, C) − v(C)]/6 = 10/3	[v(A, B, C) − v(B, C)]/3 = 40/3

4 Comparative Analysis of the Income of Cooperation and Non-cooperation

(a) *Comparative analysis of Shapley values without considering risk factors*

Shapley value algorithm considers the importance of each partner's economic income to the joint venture (from $v(s) - v(s\backslash i)$, the contribution of company i to the income of subset S can be seen), and uses this as a basis for distribution of income. The income of the three ESCOs before and after forming a corporate joint venture are shown in Table 2:

Easy to verify $\varphi_A + \varphi_B + \varphi_C \approx 60$, and $\varphi_A, \varphi_B, \varphi_C$ more than 10 thousand yuan and

$$\varphi_A + \varphi_B = 46.66 > 45 \text{ thousand yuan}$$

$$\varphi_A + \varphi_C = 39.16 > 30 \text{ thousand yuan}$$

$$\varphi_B + \varphi_C = 34.16 > 20 \text{ thousand yuan}$$

As a result, the three ESCOs form joint venture obtain more income than a single or any two of them. Besides, the joint venture allows the company to obtain additional income. Therefore, the use of network joint guarantee mode will help to not only improve the internal driving force of ESCOs joining the joint venture, but also contribute to the long-term stable development of the joint venture. In addition, ESCO A has a larger proportion of income distribution in the 600 thousand yuan, because ESCO A is more competitive than the other two. The higher the contribution rate of the company, the higher income it earns.

Table 2 Comparison table of earnings before and after ESCOs cooperation (unit: 10 thousand yuan)

Project participant	Income from non-participation in cooperation	Income from participation in cooperation	Income transform
ESCO A	10	25.83	15.83
ESCO B	10	20.83	10.83
ESCO C	10	13.33	3.33
Total	30	60	30

4.1 Comparative Analysis of Shapley Values After Risk Sharing Correction Factor

The calculation of the risk sharing correction factor needs to be considered in combination with the actual situation of each ESCO. It is a complicated process. Based on the [25] literature, this paper assumes the risk sharing ratio of each ESCO under the network joint guarantee mode to explain the risk sharing of the Shapley value algorithm. Assuming that the risk sharing correction coefficients of the three companies that have passed the algorithm of this document are:

$$R_A = 0.3,\ R_B = 0.2,\ R_c = 0.5$$

So,

$$\Delta R_A = -\frac{1}{30},\ \ \Delta R_B = -\frac{2}{15},\ \ \Delta R_C = \frac{1}{6}.$$

Then

$$\Delta v(A) = -2,\ \Delta v(B) = -8,\ \Delta v(C) = 10$$

$$v(A)' = 23.83 \text{ thousand yuan}$$

$$v(B)' = 12.83 \text{ thousand yuan}$$

$$v(C)' = 23.33 \text{ thousand yuan}$$

The changes in the earnings of the three ESCOs constituents after considering the risk factors are shown in Table 3:

Through the results of the risk sharing correction factor, it can be concluded that the correction scheme still satisfies the previous cooperation conditions, and the allocation scheme is still feasible. Besides, because ESCO C bears more risks, it gains more incremental income in the process of cooperation. ESCO B has reduced

Table 3 Comparison of earnings before and after ESCOs cooperation

Project participant	Income from non-participation in cooperation	Income from participation in cooperation	Income transform
ESCO A	25.83	23.83	−2
ESCO B	20.83	12.83	−8
ESCO C	13.33	23.33	10
Total	60	60	0

the original income that should be obtained due to less risk. The calculation result is consistent with “high risk and high return”. It also shows that the network joint guarantee mode has certain subsidy income for the risks assumed by companies, and the income distribution is more fair and reasonable.

5 Conclusion

At the present stage, due to the scale of China’s ESCOs and the scale of EPC projects, it is hard to form scale economy, which leads to the difficulty in carrying out the financing modes. The public institutions are the main force in carrying out the EPC project. The government-led network platform and the network-linked credit mode can improve the competitive advantage of the ESCOs community and alleviate the information asymmetry in financing; the joint liability of the network-linked credit, the reputation mechanism and the network information disclosure mechanism, the individual infinite joint responsibility mechanism, and the whole process review mechanism have solved the problem of insufficient guarantee in the loan and reduced the bank credit risk. The introduction of third-party testing agency has improved the project economy and accuracy of energy efficiency evaluation. All of the above can meet the financing needs of China’s EPC projects at this stage. With the analysis of Shapley value algorithm, it is concluded that under the network-linked financing mode, an individual ESCO can obtain more benefits through the joint venture than those not participating in the joint venture. The contribution of the company in the cooperation and the risk taken can also be transformed into income, thus contributing to ESCOs’ more active adoption of network joint guarantee credit mode, which further demonstrates the feasibility of this mode. As network joint guarantee credit can be an effective way to solve the financing difficulties of small and medium-sized ESCOs, it can be widely implemented in China’s huge number of small and medium-sized ESCOs to promote the faster development of China’s energy-saving services.

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China Railway Freight Price Reform Analysis: Based on Price Elasticity of Freight Demand

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Abstract Railway freight demand is a part of the railway freight market, so the understanding of this demand is the basis for the market-oriented reform of railway freight prices. The price elasticity of railway freight demand is one of the important tools to understand this demand. Therefore, based on a more reasonable freight rate calculation method and commodity demand indicator, this paper estimates the price elasticity of railway freight demand for some goods according to the commodities category of railway freight rate rules. Estimates show that the freight demand for coal and coke is inelastic while the non-metallic ore, cement and grain is elastic, which is mainly caused by the difference in transportation distance. Based on the estimated elasticity, this paper provides suggestions for the market-oriented reform of railway freight rate.

Keywords Railway freight · Demand price elasticity · Freight rate · Market reform

1 Introduction

Although demand price elasticity is a very basic economic concept, for the price elasticity of Chinese railway freight demand, we still need to understand the necessity and importance of estimating it from the historical process of freight rate adjustment (with Fig. 1).

Since the 1980s, Chinese railways have begun to relax the price control, and the rate of railway freight has risen all the way. In 1985, the railway freight rate was about 0.018 yuan per ton-km, and it was adjusted several times. In 1991, the state approved the commencement of a railway construction fund for goods transported by railways. Since 2005, on the basis of the Railway Freight Rules issued by the

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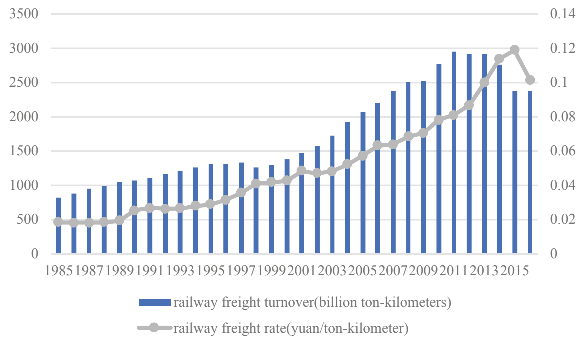

Fig. 1 The change of Chinese railway freight turnover and rate (1985–2016). *Source* Calculated with data from China Statistical Yearbook and China Railway Yearbook

Ministry of Railways, the railway has adjusted the freight rate eight times (2006, 2008 and 2009, year-on-year adjustment in 2011–2015). In 2016, this rate became 0.101.

The situation will be more specific when we compare the change between railway freight rate and turnover, which is shown in Fig. 1. We could find that, in most years, railway freight turnover grew with an similar increase of the freight rate. Of course, this anti-economic intuition phenomenon indicates that other factors which effect the freight demand exist (for example, the commodity demand). When we focus on the decrease in turnover, first slightly in 2011–2014, and then a sharp one in 2014–2016. This may reveal that the freight rate adjustment pattern of past is not sustainable anymore.

In 2017, the National Development and Reform Commission issued the [1] (NDRC Price [2017] No. 2163, hereinafter referred to as the *Notice*), requiring "deepening the market-oriented reform of railway freight rate, give full play to the decisive role of the market in resource allocation, promote the sustainable and healthy development of the railway transportation industry, and decide to expand the market adjustment scope of the railway freight rate, simplify the freight rate structure, and improve the freight rate system". The *Notice* indicates that the railway marketization is still insufficient.

Based on the freight rate adjustment process described above (this process also includes ongoing tariff reforms), the necessity to estimate demand price elasticity, is to better understand Chinese railway freight demand to avoid situation from 2012 to 2015, when faced the declining freight demand, the railway continues to increase freight rates (we believe that this anti-economic intuition behavior is caused by insufficient understanding of the demand for railway freight), happen again. In addition, since the establishment of the country until the railway freight rate was deregulated, the constant freight rate made it impossible to estimate the price elasticity of Chinese railway freight demand. Now, the change in freight rate provides the possibility to estimate this elasticity.

The importance of estimating the price elasticity of railway goods demand is: Firstly, price is the most important factor in freight demand. Our findings can help the railway to better understand the impact of price on freight demand. Second, although the market-oriented reform of railway freight rates needs to be deepened, it does not mean that the price of commodities in all categories needs to be determined by the market. It should be distinguished from the competitive and monopolistic parts of the railway transportation market, and based on this, it is concluded in [2] that whether the railway price control should be relaxed and the different price policies should be adopted. The price elasticity of demand for freight can help distinguish the competitiveness and monopoly of the rail transportation market in order to develop more targeted price adjustment and reform plans. Thus the main purpose of this paper is to estimate the price elasticity of freight demand for commodities by several categories, and to understand the commodities that are suitable for market pricing.

According to the commodity category in the Railway Freight Rate Rules, we estimate the price elasticity of railway freight demand for coal, coke, non-metallic ore, cement and grain. And we find that coal and coke, which are energy-related commodities, are inelastic. The elasticity is −0.269 for coal and −0.621 for coke. The elasticity of non-metallic ore, cement and grain is −1.164, −1.089, and −1.284, respectively, which is relatively elastic.

In 2017, the National Development and Reform Commission requested that the railway freight of cement implement market regulation prices. The conclusions of this paper on cement transportation support this policy. On the other hand, considering the market power of railway, the inelastic freight demand of coal and coke should be charged differently from the elastic cement.

The structure of the following sections of the paper: in Sect. 2, we review the existing literature. Section 3 descripts the data and the model. The result of the empirical analysis showed in Sect. 4. Finally, in Sect. 5, we will give policy recommendations based on the estimated elasticity.

2 Literature Review

Foreign scholars started earlier on the study of the elasticity of railway freight demand. Reference [3] and [4] used cross-sectional and time series data to estimate the price elasticity of demand for different goods and different modes of freight transportation in Canada. Reference [5] compared different models of freight demand and estimated the overall price elasticity of freight demand in Canada in 1979.

Unlike traditional statistical methods, reference [6] used a GIS-based approach to estimate the cost elasticity of demand for different modes of transportation and different types of goods in Europe. Reference [7] used Swedish Commodity Flow survey data (SCF) to analyze the transportation cost and time of different modes of transportation through three models, and estimated the elastic coefficient correspondingly. Reference [8] overcame the shortcomings of the previous overall transportation demand model by establishing a disaggregate freight selection model, and also use SCF data to analyze the selection of different transportation chains. Reference [9] reviewed past freight price elasticity studies and gave some new estimates. A recent study is [10] which uses the network model to estimate the price elasticity of freight demand for road, rail and inland waterways.

It can be seen that foreign scholars are constantly innovating methods and data in the specific calculation of freight price elasticity. In addition, some studies no longer estimate the elasticity itself, but based on elastic estimates, to study other issues. Such as [11] analyzed the "structural inelasticity" phenomenon in the freight transportation, that is, the lack of elasticity caused by a single mode of transportation for certain O-Ds. Reference [12] introduced the economics of regulation of railway freight rates after entering the 21st century, which mentions the importance of demand price elasticity in the formulation of regulatory policies.

It should be noted that due to the uniform pricing of China Railway Freight, it is difficult to observe the gap between the regional freight rates; in addition, the current railway cost data is kept confidential. For these two reasons, foreign scholars' methods (such as using cross-sectional data to estimate elasticity, constructing the cost function of railway freight) are difficult to adopt in the study of Chinese railways (including our paper).

It is believed that the freight rate of railway has only begun to loosen since 1984 in [13]. there has been little research on the price elasticity of railway freight transportation in China. Reference [14] established a model for optimizing the price of railway freight transportation market, linking both the demand and price of goods with the demand for railway freight transport. Reference [15] described the method of analyzing the elasticity of railway freight transportation, and proposed a multivariate linear regression model for quantitative analysis. Reference [16] analyzed the development of air transportation in Shaanxi from the perspective of demand elasticity. In order to measure the impact of economic growth on traffic volume, the elasticity of passenger and freight volume growth rate of total output value was calculated. Reference [17] proposed a programming model for the pricing of railway express freight products for the elastic demand.

Surprisingly, in addition to one research that estimates the price elasticity of freight demand specifically (which will be mentioned below), the research of price elasticity of railway freight in China are either based on the assumption of a given price elasticity of demand, or to focus on the elasticity of other factors, such as GDP growth. And they did not estimate a specific value of the price elasticity (except the one mentioned below).

The empirical research we found which estimates price elasticity of railway freight demand is reference [18], which based on the price sensitivities analysis model, controlling the development of economy.

However, this price sensitivities research is subject to several limitations. First, the dependent variable, rail freight demand, is the number of wagon with cargo loaded, and actually this variable reflects the weight of cargo loaded (ton). It is unable to capture the whole picture of freight demand, since the transportation contains two dimensions, weight and distance (so the turnover which we will use in this paper is a better choice). Second, the rail freight rate variable did not include the base price 1 (which is the price charged for cargo weight, rather than turnover. And there will be more details in Sect. 3.2). Still, just like the dependent variable, it is not comprehensive enough. Third, the cargo/commodity demand was measured by GDP, which is not a suitable measurement the demand of a particular commodity.

In short, the empirical research on price elasticity of Chinese railway freight demand is inadequate. To enrich this research field, the price elasticity of demand for freight transportation in some categories is estimated by establishing the demand function in this paper.

3 Data and Model

3.1 Railway Freight Demand

The railway freight demand is based on the data of the commodity turnover in the "National Railway Freight Transport by Sub-category" in the China National Statistical Yearbook. Since the price of railway freight varies according to the freight rate, and further, the freight rate corresponding to each sub-class in the commodity category may not be the same, thus the problem of matching the freight volume with the freight rate is generated.

Unlike [18], we choose the freight turnover instead of the number of wagons as the freight demand variable. This is because the freight turnover can better measure the demand, the shipper will not only consider the weight of the goods being transported, but also consider the distance of freight. In addition, due to the different density of different types of goods, the number of loading can not reflect the weight of the goods accurately.

In order to maintain the rigor of the analysis, we selected five types of coal, coke, non-metallic ore, cement and grain. In addition to considering the matching problem mentioned above, coal, coke, non-metallic ore and cement respectively reflect the freight of energy, raw materials and industrial goods in industrial production. As the main product of agricultural production, grain can also reflect the freight of agricultural products.

3.2 Railway Freight Rate

The price of railway freight is compiled according to the historical documents issued by the NDRC on the adjustment of railway freight rates, and is determined according to the category of commodities. According to [19]:

$$P_{\mathrm{T}} = P_1 + P_2 D \tag{1}$$

where P_T is the total freight rate (yuan/ton), P_1 is the base price 1, P_2 is the base price 2, D is the freight distance of the commodity (km). In order to get the freight

Table 1 Rail freight demand and rate for different commodities (1997–2016)

Commodity category	Freight demand sample mean (ton-kilometer)	Freight rate sample mean (yuan/ton-kilometer)
Coal	7069.26	0.063
Coke	707.09	0.064
Non-metallic ore	525.99	0.049
Cement	152.02	0.079
Grain	1424.16	0.053

Source China Statistical Yearbook and documents issued by NDRC
Note Freight rate is calculated based on the Railway Freight Transport Tariff Rules. For the calculation method, see Sect. 3.2

rate per ton-kilometer, we simply use the average freight distance of the commodity in that year to share the base price 1, therefore the railway freight price of this article:

$$P = P_1/\bar{D} + P_2 \tag{2}$$

P is the freight price of the railway (yuan/ton-kilometer), and $\bar{D}$ is the annual average transportation distance (km) of railway. In order to verify the feasibility of this calculation method, we compare the calculated price with the railway freight income rate of the same period and find no significant difference. This calculation method is reasonable.

Using this composite freight rate as a price variable can better reflect the situation faced by the shipper. Similar to the analysis of transportation needs, shippers are faced with the choice of cargo weight and shipping distance. Although the base price 2 is measured in yuan/ton kilometers, base price 1 does not take into account the freight distance (measured in yuan/ton), so it cannot be added directly. If we do not consider base price 1, it will cause errors in the freight rate measurement. With this in mind, we allocate base price 1 to the shipping distance to better determine what the shipper is facing.

3.3 Commodity Demand

The freight demand of goods is derivative demand, that is, the occurrence of freight transportation is based on the premise that the goods themselves are demanded in a certain place. Therefore, commodity demand (the demand for goods to be transported) is one of the main factors affecting the demand of freight. The measurement of this demand is more complicated. A unified indicator, such as GDP, can be used to reflect the level of demand for a particular good. However, considering that different goods have different demand conditions, it is a more accurate method to measure according to different categories of goods.

Table 2 Commodity demand indicators and time scope

Commodity category	Demand indicators	Time scope	Sample mean
Coal	Coal energy consumption (million tons)	2000–2015	2517.269
Coke	Coke energy consumption (million tons)	2000–2015	248.941
Non-metallic ore	Total energy consumption of non-metallic mining and dressing industry (million tons standard coal)	1998–2016	9.592
Cement	Cement production (million tons)	1998–2016	1287.482
Grain	Per capita food sales of rural residents (kg)	1997–2012	381.5

Source China Statistical Yearbook

For coal and coke demand, we measure their energy consumption respectively. For cement demand, use cement annual output to replace. For food demand, taking into account the characteristics of Chinese agricultural production, rural residents per capita grain sales is a better indicator than grain output, because the output is partly used for household consumption, and only the food that is sold can be transported by rail. Finally, for the demand for non-metallic ores, there is no direct indicator such as "non-metallic ore output" in the Yearbook. We choose the total energy consumption of non-metal mining industry to replace it. Given the availability of data, the specific scope of the study is as follows (Table 2):

Based on the discussion above, in order to eliminate the difference between the dimensions, we specify a log-linear model to estimate the freight demand function for each commodity category as follow:

$$\ln Q = \alpha + \beta \ln P + \gamma \ln q + \mu \tag{3}$$

where Q is railway freight demand, P is railway freight price, and q is the commodity demand (the demand for goods to be transported), which the freight demand, Q is derived from q. α is the constant term, μ is the error term, β and γ represent the price elasticity and the commodity demand one, respectively.

4 Result and Discussion

4.1 Regression Result

Table 3 shows the regression result. The R-squared of the coal and coke models are 0.9643 and 0.9502, respectively, indicating that the model fits well; the R-squared of the grain model is 0.8926, which is lower than the energy model, which may be caused by the error of the substitution variable of the commodity demand. The R-squared of the non-metallic ore and cement models are 0.7761 and 0.7836, respectively,

Table 3 Regression results

Commodity category	Independent variables	
	Rail freight rate	Commodity demand
Coal	-0.269^{**} (0.124)	1.122^{***} (0.111)
Coke	-0.621^{**} (0.141)	0.948^{***} (0.093)
Non-metallic ore	-1.164^{***} (0.176)	1.636^{***} (0.290)
Cement	-1.089^{***} (0.164)	0.505^{***} (0.111)
Grain	-1.284^{***} (0.378)	2.060^{***} (0.353)

Note Standard errors in parentheses. (**) represents statistically significant at the 5% level. (***) represents statistically significant at the 1% level

indicating that the total energy consumption of the non-metallic mining industry and the annual output of cement have limited interpretation of their respective needs.

All demand price elasticity is negative, and the coefficient of the commodity demand variable is positive, which is consistent with economics. That is, the higher the price, the less the demand; and the more demand for the commodity themselves, the greater the demand of freight generated. Specifically, the elasticity of coal and coke are -0.269 and -0.621, respectively, which represent inelastic demand; the elasticity of non-metallic ore, cement and grain are -1.164, -1.089 and -1.284, respectively, which represent elastic demand.

The coefficient of commodity demand is positive, but the gap between different categories is very large. For example, the coefficient of grain reaches 2.060, and as for cement, the coefficient is only 0.505. In addition to the problems in the selection of indicators, it is largely because the freight demand is measured by the turnover volume, and the unit is ton-kilometer, which includes both the weight and distance. It is noted that the average transportation distance of grain in the period of 1997–2016 is 1,590 km, while the same indicator of cement is only 419 km, which is conducive to road transportation. It can therefore be inferred that the difference in the coefficient of commodity demand can be explained by the difference in the average distance. This result shows that the commodity demand indicator we selected is reasonable to some extent.

In order to confirm our analysis in Sect. 3, we compare the results with the same commodity category in reference [18] we mentioned before, we use GDP to measure the demand of goods (consistent with reference [18]), and estimate the price elasticity of freight demand again.

The column 1 in Table 4 is the price elasticity estimated in [18], the column 2 is the freight elasticity with the commodity demand as the control variable (same with Table 3), and the column 3 is the estimation with GDP.

It can be seen that the elasticities estimated in this paper is higher than the estimation result of [18] (in absolute value). It is worth noting that the price elasticity of coal and coke in [18] is not statistically significant, indicating the variables used, including the number of wagons that measure the freight volume, the base price 2

Table 4 Results comparison

Commodity category	Elasticity estimation in reference [18]	Elasticity estimation with commodity demand	Elasticity estimation with GDP
Coal	0.2886	−0.269**	−0.926**
Coke	−0.0847	−0.621***	−1.228***
Non-metallic ore	−0.527***	−1.164***	−1.292***
Cement	−0.4686***	−1.089***	−1.194***
Grain	−0.5841***	−1.284***	−1.429***

Note 1 (**) represents statistically significant at the 5% level. (***) represents statistically significant at the 1% level
Note 2 Coal estimation result in column 1 is positive

that measure the freight rate, and the GDP as a control variable, may face some problems.

The estimation results in the column 3 are all higher than the corresponding categories in the column 2 (in absolute value). The estimation result of the coal increased by 244% in absolute value and 98% in coke, while the other three categories increased by 2.6, 18.6 and 11.3% respectively. Because we measure the demand for coal and coke with energy consumption, which is a more accurate indicator than GDP, so it is reasonable to believe that the estimation results in the column 2 is better.

GDP overestimated the impact of freight rates on coal and coke freight demand, because the GDP was growing while the freight demand of coal and coke has declined to some extent after 2011, and the consumption of coal and coke in 2011 is different from the growth of GDP either.

4.2 Interpretation of the Results of the Sub-category

According to different commodity categories, our interpretation of the elasticity estimation results is as follows. We believe that freight distance is an important cause of the difference.

- Coal: The distribution of coal resources in China is very uneven. The resources in the north of the Dabie-Qinling-Kunlun Mountain area account for 94% of the country's total. While Xinjiang, Neimenggu, Shanxi, and Shaanxi account for 81.3% of the country's total. In the south, Yunnan, Guizhou and Sichuan account for 90% of the total reserves in the South as in [20].

From the perspective of coal demand, the eastern and southern coasts are major consumption areas. The separation of supply and demand makes coal more long-distance transported, and the railway has a strong monopoly power in this field.

Although the shipping also has advantages in long-distance transportation, since the coal producing areas are located in the central and western regions, the shipping and railways are more of a joint transportation relationship than competition. This can explain the lack of elasticity in railway coal freight demand.

- Coke: The situation of coke is similar to that of coal. Coke is made from a kind of coal called coking coal, so the origin of coke is similar to that of coal. As the basic raw material for blast furnace metallurgy, coke is the main demand for steel industrial. In China, it is mainly concentrated in iron ore producing areas such as Liaoning, Hebei and Anhui in [21]. The lack of elasticity in coke railway freight demand is also caused by the lack of intermodal competition. The advantages of railways in this region can be reflected in the long transportation distance and the developed railway network in Northeast China and North China.
- Cement: The raw material of cement is mainly limestone, and the limestone mine is basically distributed in all provinces of China. The distribution of cement plants is also very extensive. In addition, the value of cement products is not high, so the transportation of cement is mainly in the middle and short distance as in [22]. This is a market area where railway has a weak monopoly power. The competition brought by road transportation has increased the elasticity of cement railway freight demand.

In addition, the Yangtze River Basin is a dense area of limestone mines, so inland water transportation also increases the intermodal competition.

- Non-metallic ore: Here we focus on two types, pyrite and limestone. Limestone has been discussed in detail when analyzing cement and will not be described again. Pyrite is evenly distributed throughout the country. In 2016, the reserves of pyrite in Neimenggu, Anhui, Guangdong, Jiangxi and Sichuan exceeded 80 million tons, while the number of provinces with reserves exceeding 10 million tons was 16.

All in all, the uniform distribution of non-metallic ores will lead to a lack of monopoly in rail transportation, and the intermodal competition will increase the elasticity of railway freight demand.

- Grain: The railway transportation of Chinese grain is mainly in the middle and long distance. It mainly starts from the northeast region, crosses the Shanhaiguan (Hebei province), and through the railway lines of Beijing-Shanghai, Beijing-Kowloon (Hong Kong) and Beijing-Guangzhou to the southern grain sales area. In south of Shanhaiguan, including grain transportation produced in the Huang-Huai-Hai area, it relies on trucks and small vessels (to reach the southern grain sales area).

In addition, there is competition for shipping in medium and long distance transportation as in [23]. It can be argued that the high elasticity of grain railway freight demand mainly comes from intermodal competition, regardless of the transportation distance.

The above analysis confirms the fact that among the transportation models of bulk commodities, namely roads, railways and waterways. Waterway is restricted by the natural environment, and the main competitor of the railway is road transportation.

5 Conclusions

In this paper, to get a better understanding about the freight price and freight market. In the context of the multiple adjustments of Chinese railway freight rates, the price elasticity of railway freight demand is estimated according to the commodity category. The estimation results show that coal and coke are inelastic, with −0.269 and −0.621, respectively. And the elasticity of non-metallic ore, cement and grain is relatively large, −1.164, −1.089 and −1.284, respectively.

After comparing with the existing research, considering that China has a long-term tariff control (and this regulation is currently only relaxed, not banished), and a limited data set, we believe that this paper can better reflect the impact of price on freight demand.

About this paper, it is worth noting that the adjustment of freight rates do exist, but this adjustment is not carried out every year. Therefore, the price variable is actually discrete. We use the freight distance to add the base price 1 into the overall freight rate, so that the price variable is continuous. This can better reflect the shipper's decision-making because they consider not only the weight of the goods, but also the distance shipped. At the same time, this is why we choose the cargo turnover as an indicator of freight demand.

Considering that the railway is basically an exclusive monopoly in China, there is no competition within the model. Therefore, the price adjustment and the inter-modal competition bring about the difference in the railway freight demand elasticity. Specifically, for coal, coke and other that the place of production is concentrated and/or away from the demand side, the railway has a strong monopoly power. And for goods scattered, or closer to the demand, the competition caused by roads and water transportation reduced the monopoly power of the railway.

For the inelastic goods, the price of railway freight should be regulated to avoid excessive transportation costs caused by the monopoly. In particular, after the implementation of the "Shifting from Road to Rail" policy, the monopoly of the railway will be further strengthened.

On the other hand, for the elastic goods, the freight rate should be deregulated as much as possible, so that the railway can be priced according to the market, and reduce restrictions on other forms of competition such as road transportation, which can improve the efficiency of railway transportation and reduce price distortion.

On the basis of this paper, the research on the price elasticity of Chinese railway freight demand should be paid more attention. There are many aspects worthy of improvement and development, including but not limited to: estimation of the price elasticity of transportation demand for more types of goods; improvement of the selection of commodity demand (the demand for the goods to be transported) indicators; cross-elasticity between different modes of transportation.

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Empirical Research on the Ultimate Controlling Right, Cash Flow Rights and Tax Avoidance Strategies Style

Chengren Liu and Wei Wei

Abstract This paper takes the 2008–2015 China-Shenzhen A-share private listed company as the research object, and analyzes the impact of the ultimate controlling power, cash flow rights and the separation degree of the two on the tax avoidance strategies empirically. The study finds that the ultimate controlling of private enterprises is positively correlated with the tax avoidance strategy style. There is no obvious correlation between cash flow rights and tax avoidance strategies style, but the degree of separation between ultimate control rights and cash flow rights is positively related to corporate tax avoidance strategy style. It means that the more dramatical the separation of ultimate controlling right and cash flow rights is, the more radical the company's tax avoidance strategies style will be.

Keywords Ultimate controlling right · Cash flow rights · Tax avoidance strategies · The separation of ultimate controlling rights and cash flow rights

1 Introduction

Reform and opening up into a new era, China's socialist market economy continue to develop; the capital market is constantly improving, the government has also introduced a series of preferential policies in due course to support the development of private enterprises. Of course, for enterprises, but also bear the responsibility of paying taxes to the state, but the reality is that some enterprises, especially private enterprises in order to seek their rapid development, has a strong incentive to carry out tax avoidance activities to reduce their taxes [1]. Therefore, it is necessary to study the tax avoidance strategy style of enterprises. Since the age of the century, the first type of agency problem of shareholders and managers caused by the dispersion

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of equity has not been the focus of today's researchers, and a growing number of scholars around the world have shown that there are controlling shareholders in companies In most countries [2], there is the phenomenon of concentration of equity. Combining with the present situation of domestic research, Degui Su and other points out that under the environment of China's socialist market economy, there is also a phenomenon of high concentration of equity in enterprises, which shows that the control of controlling shareholders and the deviation of cash flow rights are serious, which leads the controlling shareholders to encroach on the interests of minority shareholders, and the problems are more prominent [3]. Under the mode of enterprise equity concentration, because of the separation of cash flow right and control right caused by the difference of the nature of company ownership and control right, that is, the large controlling shareholder shares the cash flow power with the small and medium-sized shareholders according to the shareholding ratio, and obtains the controlled economic resource which exceeds the cash flow value through the pyramidal ownership structure to obtain additional benefits higher than the proportion of shares held [4]. Domestic researchers Hu and others also found that the ultimate controller of domestic private listed companies mostly tends to adopt pyramidal holding methods [5], in order to obtain greater control of the company with smaller cash flow rights. Under such an equity system arrangement, shareholders with control will often take various measures to obtain additional benefits, tend to carry out tax avoidance activities, both tax avoidance activities will have risks and benefits, which need to be weighed, so tax avoidance activities should be seen as a strategic action to plan. That being the case, what kind of tax avoidance strategy would a controller with ultimate control prefer? Moreover, what kind of style will be preferred when the ultimate control person's control is separated from the cash flow right, which is the problem to be emphatically expounded in this paper.

The reason why the listed private enterprises are selected as the research object is that the controllers of private enterprises will be more inclined to obtain economic benefits and emphasize the maximization of benefits, so there is a stronger motivation to achieve the goal through tax avoidance activities. Compared with state-controlled enterprises, the assets of private listed companies are in the hands of individuals, and the personal preferences of the controlling persons will have a strong impact on tax avoidance behavior [6]. Therefore, this paper studies the influence of the ultimate control right of private enterprises and the cash flow right and the degree of separation of the two on the strategic style of tax avoidance.

2 Theoretical Analysis and Research Hypothesis

2.1 *Ultimate Controlling Right and Tax Avoidance Strategy Style*

In the enterprise, the ultimate control right refers to the control right owned by the ultimate controller, which holds the decision-making power of the company, and there are two kinds of motives in the operation of the enterprise, one is to take the interests of the company as the first, and not to adopt the tax plan that is, to adopt the tax avoidance strategy to gain self-interest At the same time, it is also to be able to share the company's larger benefits. The other is that the ultimate controller is more inclined to adopt a tax avoidance strategy to obtain additional economic benefits than the annual earnings dividend, which will no doubt encroach on the interests of other small and medium-sized shareholders in the company. Ma and Chen [7] The study found that when the controlling shareholder was at a relative holding level (the control it owned was about 30–50%), despite the existence of ownership (as measured by the right to cash flow), "Incentive effect", but the separation degree between the final control right and the cash flow right will lead the controlling shareholder to seek the control self-interest and obtain the additional benefit. Wang and Chou [8] through the study, it is found that there is a negative "encroachment effect" in the control of controlling shareholders in enterprises [9], and with the increase of control rights, The motives for controlling people will be more complicated, they will weigh the cost of encroachment against the benefits obtained, and analyze the often used tax avoidance, which will result in different tax avoidance strategies, so that the size of the ultimate control will affect the choice of tax avoidance strategy when other conditions are certain. Therefore, this paper presents the following hypothesis 1:

H1: Under the premise of the same conditions, the greater the control of the ultimate controller, the easier it is to adopt a tax avoidance strategy that is biased towards risk, that is, it is positively correlated.

2.2 *The Degree of Separation Between Ultimate Controlling Right and Cash Flow Rights and the Choice of Corporate Tax Avoidance Strategy*

Existing research has found that in most listed companies, there are ultimate controllers, and most of the ultimate controllers are "pyramid" equity models. To conduct corporate governance, which leads to the separation of control rights and cash flow rights. Due to the special structural design, the controlling shareholder's control power is often greater than its cash flow rights. The ultimate controlling shareholder constructs a complex control chain through the pyramid structure so that it can obtain greater control of the listed company with a smaller cash flow [2]. This kind of corporate governance structure means that the ultimate controller can control the capital of listed companies with less capital investment so that they have stronger motives to encroach on the interests of small and medium shareholders. Tax avoidance strategy, and the greater the degree of separation between control and cash flow rights, the stronger the motivation of the ultimate controller to encroach on the interests of small and medium shareholders, and the more inclined it is to adopt radical measures in tax avoidance activities. Especially in an emerging market-oriented country like China, private enterprises have a high concentration of equity, and the degree of protection for investors is relatively weak. Enterprises adopt pyramid structure holding, and the separation of control rights and cash flow rights is serious [10]. Domestic researchers Su Kun and Shuzhen Yang found through research that for listed private companies with the separation of ultimate control rights and cash flow rights [11], controlling shareholders have more preference for debt financing behavior, to expand the resources that can be deployed and controlled. In the acquisition of controlled private interests, the implementation of encroachment. It can be seen that the more serious the separation of the ultimate control right and the cash flow right, the more the controlling shareholder tends to take tax avoidance activities to obtain additional income. Therefore, this paper proposes the following hypothesis 2:

H2: Under the premise of the same conditions, the greater the degree of separation between ultimate control rights and cash flow rights, the more private listed companies tend to adopt a radical tax avoidance strategy style, showing a positive correlation.

3 Research Design

3.1 Sample Selection and Data Source

This paper takes the Shanghai-Shenzhen A-share listed private companies from 2008 to 2015 as the research object, selects the data during the period for analysis, and selects them according to certain conditions, excluding ST companies and companies with missing relevant data; excluding financial insurance companies because of finance The insurance industry implements accounting systems and standards that are different from other industries; companies that exclude financial data and loss of ownership information; and 661 companies have been screened for a total of 3,916 observations. The data source is the CSMAR Guotai'an database.

3.2 Variable Definition

Explain variable, the ultimate control right represents the controlling shareholder's control over the company, measured by total voting rights (VR), the ratio is equal to the sum of the smallest equity ratio in each control chain [1], cash flow rights (CR).

Table 1 Research scalar description

Variable	Index	Symbol	Definition
Explained variable	Tax avoidance strategy style (tax avoidance)	ETR	Current income tax expense/pre-tax accounting income
Explanatory variables	Control	VR	Ultimate controller's voting rights
	Separation of control rights and cash flow rights	DIV	Control/cash flow rights
Control variable	Company size	SIZE	Natural logarithm of total assets
	Assets and liabilities	LEV	Long-term debt as a percentage of total assets
	Roe	ROA	Net profit as a percentage of total assets
	Capital intensity	CINT	Net assets (factory and equipment as a percentage of total assets)

It can be expressed as the proportion of the ultimate shareholder's cumulative ownership of the company through the various control chains. The degree of separation (DIV) between the ultimate control and the cash flow rights can be expressed as control/cash flow rights.

Interpreted variables are tax avoidance strategy styles, and different tax avoidance strategy styles represent different tax avoidance behaviors. Researchers at home and abroad usually choose the actual income tax rate (ETR) as a quantitative indicator of tax avoidance behavior. The actual income tax rate refers to the ratio of the income tax burden of the enterprise to the pre-tax economic income. This article draws on Calculation method: Get $ETR =$ income tax expense/pre-tax accounting profit (book profit) [12]. The smaller the value of ETR, the higher the tax avoidance and the more tax avoidance strategy style tends to risk preference.

Control variables, in order to control the influence of other factors, this study considers the following control variables: company size (SIZE), asset-liability ratio (LEV), return on equity (ROA), capital intensity (CINT), this article refers to The variables are shown in Table 1.

3.3 Model Building

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

In order to verify hypothesis 1, this paper constructs the following model (1):

$$ETR_{i,t} = \beta_0 + \beta_1 VR_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 LEV_{i,t} + \beta_4 ROA_{i,t} + \beta_5 CINT_{i,t} + \varepsilon. \tag{1}$$

In order to verify hypothesis 2, this paper constructs the following model (2):

$$ETR_{i,t} = \beta_0 + \beta_1 DIV_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 LEV_{i,t} + \beta_4 ROA_{i,t} + \beta_5 CINT_{i,t} + \varepsilon, \tag{2}$$

where i denotes the i-th company and t denotes the period between 2008 and 2015, β represents the estimated regression coefficient of each variable.

4 Empirical Analysis

4.1 Descriptive Analysis

Table 2 is the descriptive statistical result of the main variables. From Table 2, we can see that the average shareholder control (VR) of private listed companies in China is 43.7%; the cash flow rights (CR) are lower than the control rights. The average value is 38.6%. When the control right exceeds the cash flow right (ownership), the average degree of separation of the cash flow rights and voting rights (DIV) is 1.234, which indicates that there is indeed a separation of control rights and cash flow rights among private listed companies in China.

Table 2 Descriptive statistics of research variables

Variable	Sample size	Minimum value (M)	Maximum (X)	Average value (E)	Standard deviation
ETR	3916	0	1	0.160	0.399
VR	3916	0.080	0.919	0.437	0.156
CR	3916	0.025	0.846	0.386	0.164
DIV	3916	0.441	10.000	1.234	0.500
SIZE	3916	18.524	26.724	21.435	0.915
LEV	3916	0.000	0.892	0.041	0.076
ROA	3916	−0.336	0.292	0.044	0.065
CINT	3916	0.005	0.600	0.040	0.137

Table 3 Model summary

Model	R^2	Adjustment R^2	Standard estimated error
1	.876	.865	9.37904

Note Predictors: (constant), VR, CR, SIZE, ROA, CINT, LEV

4.2 Goodness of Fit Test

According to the results in Table 3 below, R^2 is used as an index to test the goodness of fit between the regression equation and the sample value. The coefficient of the model is $R^2 = 0.876$. Since the model introduces multiple independent variables, the number of independent variables may increase. Let R^2 increase, in order to eliminate the influence of the increase of the number of variables on the increase of R^2, use the adjusted R^2 to see the degree of fitting of the regression equation.

The adjusted judgment coefficient $R^2 = 0.865$, which means that the fitting degree of the equation to the research problem is 86.5%, which can explain the problem better, so the regression equation fits well, that is, the change of the independent variable to the dependent variable Great impact.

4.3 Regression Analysis

(a) *The regression analysis model of control and tax avoidance strategy style:* From the regression analysis results in Table 4, shows that the regression coefficient of VR and ETR is significantly negatively correlated, that is, the larger the value of VR, the smaller the value of ETR, that is, the lower the effective tax rate. That is to say, the greater the control right, the more obvious the tax avoidance behavior, and the more the tax avoidance strategy style is radical. Therefore,

Table 4 The regression analysis of controlling and tax avoidance strategies style

Model		Non-standardized coefficient		Standard coefficient	t	Significant
		B	Standard error	Beta		
1	Constant	−0.114	0.174		−0.655	0.513
	VR	−0.044	0.211	−0.017	−0.210	0.034
	SIZE	−0.013	0.008	−0.029	−1.622	0.055
	LEV	−0.101	0.099	−0.019	−1.023	0.306
	CINT	0.004	0.052	−0.001	−0.073	0.942
	ROA	0.140	0.106	0.023	1.321	0.187

Note Interpreted variable ETR

Table 5 The regression analysis of the separation and tax avoidance strategies style

Model		Non-standardized coefficient		Standard coefficient	t	Significant
		B	Standard error	Beta		
1	Constant	−0.174	0.169		−1.031	0.303
	CR	0.026	0.045	0.011	0.577	0.564
	DIV	−0.023	−0.015	−0.028	−1.538	0.024
	SIZE	−0.013	0.008	−0.031	−1.722	0.085
	LEV	−0.098	0.098	−0.019	−0.995	0.320
	CINT	0.000	0.052	−0.000	−0.006	0.996
	ROA	0.136	0.106	0.022	1.283	0.200

Note Interpreted variable ETR

hypothesis 1 is verified: the control of the ultimate controlling shareholder is positively related to the tax avoidance strategy style.

(b) *The regression analysis model of the separation of two powers and the style of tax avoidance strategy:* Table 5 gives the regression results of the degree of separation of control rights and cash flow rights and the style of tax avoidance strategy. As shown in Table 5, the variable DIV and ETR are significantly negatively correlated numerically, that is, the larger the value of DIV, the smaller the value of ETR (the lower the effective tax rate). Explain that the greater the separation of the ultimate control rights and cash flow rights, the more the tax avoidance strategy prefers risk. Therefore, Hypothesis 2 is verified: the degree of separation of ultimate control rights and cash flow rights is positively correlated with tax avoidance strategy style. From the regression results, we can also see that the significance test of CR and ETR is $P > 0.05$, indicating that cash flow rights have no obvious correlation with tax avoidance strategy style.

(c) *Robustness test:* In order to further test the reliability of the above regression results, this paper uses the following method to test the robustness: for the tax avoidance strategy style, it is still measured by the effective tax rate, but the calculation adopts another calculation method, namely $ETR_2 =$ cash tax/pre-tax accounting income The regression results of DIV and ETR2 are significantly negatively correlated, that is, the larger the DIV value, the smaller the ETR2, indicating that when the separation of the ultimate control right and the cash flow right is large, the tax avoidance strategy style tends to risk preference and hypothesis 2 Match. That is to say, the regression results have not changed substantially, so the research conclusions have strong robustness.

5 Conclusions

This paper takes the 2008–2015 China Shanghai, and Shenzhen A-share listed private companies as the research object, empirically tests the impact of the ultimate control power, the degree of cash flow separation on the tax avoidance strategy style, and the relevance of the ultimate control power to the tax avoidance strategy style. It is found that the degree of separation between the two rights is significantly positively correlated with the tax avoidance strategy style, and the ultimate control power is also positively correlated with the tax avoidance strategy style. The conclusions of this paper not only theoretically expand the related research on the influencing factors of tax avoidance strategy style but also help to provide a reference for how to detect tax avoidance behavior. On this basis, the paper proposes the following suggestions: (1) As a government taxation department, it is necessary to pay more attention to companies that use the pyramid ownership structure to lead to a serious separation of control rights and cash flow rights, because they are more motivated to adopt tax avoidance behavior to obtain private ownership. Benefits provide a new direction for the tax authorities. (2) For the governance of listed companies under the pyramid structure, the interests of the small and medium-sized shareholders are also damaged. Therefore, when selecting a listed company for investment, in addition to paying attention to common reporting indicators, it should also pay attention to the ultimate control and cash of a company. The degree of separation of the right to flow and the tax avoidance strategy style it affects are used as the basis for judging the future value and performance of the company. (3) Regarding corporate governance, it is necessary to pay attention to the construction of internal control system, implement effective supervision, pay special attention to the separation of controlling shareholder's control rights and cash flow rights, and avoid damage to its value and corporate image through tax avoidance activities.

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How Does Urbanization Affect the Real Estate Demand?

Jiening Meng

Abstract In order to analyze the mechanism of urbanization on the real estate market in detail, this paper considers the regional nature of the real estate market, constructs a dual logarithmic demand function, analyzes the impact of multidimensional urbanization on the real estate demand. The results show that economic, population and spatial urbanization can all increase the demand for real estate, but its impact mode and degree are different: the incremental effect of population urbanization and the income effect of economic urbanization have the greatest contribution to real estate demand. Apart from the impact of population factors, economic urbanization, especially the increase of per capita income level, is the main driving force for the increase of per capita real estate demand. Spatial urbanization embodied by the agglomeration of urban resources and improvement of infrastructure has a positive effect on real estate demand, and investment in fixed assets other than real estate development has the greatest effect.

Keywords Multidimensional urbanization · Incremental effect · Income effect · Real estate demand

1 Introduction

Urbanization is a process in which human production and lifestyle change from rural to urban. During this period, population, capital, land and other factors continue to gather in cities, and the number and size of cities change. Real estate is the place where urban residents produce and live, and also the space bearing of urbanization. Under the framework of multidimensional urbanization, population and economic urbanization affect real estate demand, spatial urbanization reflected by real estate development changes real estate supply. It can be seen that urbanization acts on

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urban real estate market from both supply and demand sides. Different urbanization characteristics reflect different real estate resource allocation status. Then, how does the dynamic urbanization process affect the real estate market? Considering the regional nature of the real estate market, using the data of urbanization and real estate market in 35 large and medium-sized cities of China from 2006 to 2018, this paper establishes a double logarithmic demand function, analyses the impact of multidimensional urbanization on real estate demand, it also makes a judgment on coordinated urbanization from the perspective of housing balance, so as to provide theoretical basis and policy reference for the accurate control of the real estate market and the establishment of long-term real estate mechanism.

2 Literature Review

The academic research on urbanization and real estate market involves causality, action mechanism and coordination, etc. From the perspective of promoting the formation of research ideas in this paper, it is mainly reflected in the following aspects:

Urbanization level and real estate market. Domestic and foreign scholars generally believe that there is a long-term stable positive change relationship between urbanization level and real estate market: on the one hand, the level of urbanization is positively correlated with real estate supply and demand [1, 2], but not pure linear relationship, when the level of economic growth exceeds a certain threshold, the effect of urbanization on the growth of real estate market demand will be reduced [3]; On the other hand, the development of real estate industry can accelerate the process of urbanization, and its role is stronger than that of urbanization in promoting the development of real estate industry [4].

Urbanization connotation and real estate market. Urbanization is a multidimensional and integrated process including economic urbanization, population urbanization and spatial urbanization. There is a complex and subtle relationship between urbanization and real estate supply and demand: Yang and others found that urban basic housing demand is equal to the product of the total urban population, the number of housing units per household, urbanization rate and the reciprocal of household size [5]. The demand for new basic housing is synchronized with the urbanization speed of the population; From the perspective of demographic structure, li et al. predicted that the overall demand for housing in Chinese cities in the future would present “rise-stable-decline” an “inverted u-shaped” feature [6]. Zhao et al. pointed out that whether or not the labor flows to the city or to which city depends on three factors: salary, rent and comfort level [7]. Cities with high level of economic development can attract a large number of working population due to more employment opportunities and higher level of public services, while other cities are second. Jiang et al. measured the situation of the major urbanized areas in China and found that the population did not flow to all cities at the same speed or scale, but gathered in the major urbanized areas on a large scale in the past decade [8]. Spatial urbanization not only guarantees the supply of urban real estate [9], but also has a vital impact on the allocation structure of real estate resources [10]. Therefore, it is necessary to seek new paths and new methods for the supply and demand balance of the real estate market in the process of multidimensional urbanization. To adjust the development thinking of urbanization, scientifically predict the size of urban population based on the objective law of population flow, and rationally allocate urban resources are the top priorities of urban construction [11]. Therefore, in the process of intensive urbanization, it is necessary to find a new way and method to balance the supply and demand of the real estate market.

Urbanization coordination and real estate market. Real estate is space-immovable, under the background that population and capital can flow, the urban real estate market is faced with competitive demand and monopolistic supply, which makes its supply and demand usually do not match. Therefore, promoting the coordinated development of urbanization and real estate market is a concern of many scholars. Sun et al. constructed evaluation index based on the concepts and connotations of population, economic and spatial urbanization, evaluated the degree of coupling and coordination among them, its evolution law and mechanism of action, and found that the coupling and coordination of multidimensional urbanization and its mutual coupling and coordination were largely influenced by national macro-control, policy reform and local government behavior [12]; Xue et al. measure the comprehensive urbanization level of Chinese cities in 2007 by combining population, economic and spatial urbanization, divided the whole country's cities into three categories and nine sub-categories: balanced development type, more balanced development type and unbalanced development type, and revealed the main problems of each type from the perspective of coordination of urbanization system [9]; Cai analyzed the causes of the inconsistency between spatial urbanization and population urbanization from the perspective of cost-benefit of local government [13]; Zhu made a comprehensive study of the interaction between urbanization quality and urban housing price, and found that the soaring house price and inventory backlog all originated from the quality of urbanization [14]; Xie et al. conducted a comprehensive measurement of Shanghai's urbanization level and the development level of the real estate market through principal component analysis, and studied the long-term co-integration and short-term dynamic mechanism of Shanghai's urbanization process and real estate development, and put forward the countermeasures to promote the coordinated development of urbanization and real estate industry in Shanghai [15].

Relevant studies have revealed the impact of urbanization on the real estate market from different perspectives, and the main conclusions include: there is a positive correlation between urbanization and real estate demand or real estate price; urbanization acts on real estate market from both ends of supply and demand; different urbanization characteristics reflect different supply and demand patterns of real estate market; uncoordinated urbanization will lead to real estate market problems. It is necessary to promote the coordinated development of urbanization and real estate market. These research results have laid the foundation for the formation of this thinking, but considering the particularity of real estate, focusing on the process of real estate resource allocation rather than results, research on the mechanism of dynamic multidimensional urbanization on the real estate market is not perfect enough. This paper considers the characteristics of urbanization and real estate market attempts to further elaborate the mechanism of economic, population and spatial urbanization on the real estate market, and discuss the impact of different effects on the real estate demand, so as to provide theoretical basis and policy reference for the establishment of "one city one policy" and the long-term real estate mechanism of real estate.

3 Theoretical Analysis and Hypothesis

One of the hallmarks of urbanization is the expansion of the size of the city. The essence of the urban economy is the economies of scale that result from the accumulation of various factors. After the reform and opening up, China has gradually relaxed the restrictions on population movement. Cross-regional and cross-urban population movement has become a common phenomenon. However, whether or not the population flows to the city or to which city depends on the urban development, including income level, economic structure, housing prices, public resources, environment and policy constraints. In this process, economic, population and spatial urbanization are mutually causal, but in terms of real estate demand, the role of urbanization is as follows: population urbanization increases urban population, The demand for real estate is increasing, under the influence of urban residents' demand for "living and working in peace and contentment" the real estate demand increases. Economic urbanization leads to the improvement of per capita income level and industrial structure, and at the same time attracts a large number of labor population to flow into cities. Under the combined effect of income effect and incremental effect, the demand for real estate increases. Although spatial urbanization mainly reflects the supply of real estate, but with the improvement of infrastructure, the agglomeration and optimization of medical, health, cultural and educational resources, the population attraction of urban increases and the demand for real estate also increases. In order to verify the impact of multidimensional urbanization on the real estate market, this paper proposes hypothesis 1.

H1: Economic, population and spatial urbanization all lead to the increase of urban real estate market demand.

Real estate has both residential and investment functions, so it is faced with residential and investment demand. Residential demand, also known as urban basic housing demand or rigid demand, which is determined by factors such as total urban population and per capita living area. In order to investigate the impact of real estate resource allocation reflected by multidimensional urbanization process and its characteristics on real estate demand, and explore the conditions for coordinating urbanization, this paper constructs a real estate market equilibrium model which only considers residential demand:

$$\begin{cases} Q_{dt} = A_{t-1}(pop_{t-1} + \Delta pop)(1+\sigma) \\ Q_{st} = Q_{st-1} + \Delta s \\ Q_{dt} = Q_{st} \end{cases} \tag{1}$$

Q_{dt} represents residential demand, A_{t-1} and pop_{t-1} are the per capita housing use area and the total urban population in the previous period, Δpop is the total population change of t period, σ means the demand for improved housing, which is generally positive constant and reflected by the growth rate of urban per capita housing use area. Q_{st} stands for real estate supply, which is the sum of urban stock housing Q_{st-1} and new housing supply Δs. Regardless of depreciation, Δs is calculated by the accumulative completed housing area of the city in t period. In the framework of comparative static analysis, the market clears out, so $Q_{st-1} = Q_{dt-1}$, the equations are solved:

$$\Delta s = \sigma A_{t-1} pop_{t-1} + A_{t-1} \Delta pop(1+\sigma) \tag{2}$$

That is to say, the new real estate supply should be the sum of the improved housing demand and the new housing demand. Order $A_{t-1}pop_{t-1} = s_0$, $pop_{t-1} = pop_0$, the above formula can be converted into (3):

$$\frac{\Delta s}{s_0} = \sigma + \frac{\Delta pop}{pop_0}(1+\sigma) \tag{3}$$

In (3), $\Delta s/s_0$ is the growth rate of housing supply. Since spatial urbanization is largely reflected by the rapid development of real estate industry, it can be regarded as the speed of spatial urbanization, which is indicated by V_{su} below. $\Delta pop/pop_0$ represents the population urbanization speed, which is indicated by V_{pu} below. The above formula is further simplified to (4):

$$V_{su} = \sigma + ((1+\sigma))V_{pu} \tag{4}$$

If it is regarded as an exogenous variable of V_{pu}, take the derivatives of both sides of (4), and get $dV_{su}/dV_{pu} = 1 + \sigma \neq 0$. It can be known that (4) is the implicit function of spatial urbanization speed and population urbanization speed, that is, the condition that coordinated urbanization should meet when only considering housing demand. Among them, $\sigma + (1+\sigma)\, V_{pu}$ is a linear function of population urbanization speed, which reflects the change of urban basic housing demand, but the model lacks the explanation of σ, this paper proposes hypothesis 2.

H2: Economic urbanization leads to an increase in per capita real estate demand.

4 Model and Data

4.1 Double Logarithmic Demand Model

Because house prices are soaring and inventory backlog is very common, it is difficult to describe the real estate market with the local equilibrium model. This paper uses the analysis methods of Gao B. and Kuang W. to establish dual logarithmic demand function including housing demand and investment demand. Analyze the impact of housing price, total population, per capita income, industrial structure, infrastructure and public resource allocation on real estate demand. These factors also reflect the status of population, economic and spatial urbanization respectively. Therefore, take it as explanatory variable, the demand function can explain the impact of multidimensional urbanization on real estate demand, the specific form of the model is shown in formula (5):

$$\ln Qit = \beta 0 + \beta 1 \ln Pit + \beta 2 \ln Iit + \beta 3 \ln Popit + \beta 4 \ln \mathrm{Re}sit + \beta 5 Envirit + \varepsilon it \tag{5}$$

In (5), *i* represents the city, *t* represents the year, *Q* represents the demand of real estate market and *P* is the house price; *I, POP, Res* and *Envir* are the explanatory variables representing the per capita income level, total population, resource and environmental constraints of the city; β is the coefficient to be estimated, ε is the random perturbation term. Model (5) can explain the overall effect of multidimensional urbanization on the demand of real estate market, but it is not specific enough to analyze the effect of urbanization on housing demand. Therefore, we further exclude the role of population urbanization and constructs a per capita real estate demand function, as shown in (6).

$$\ln qit = \beta 0 + \beta 1 \ln Pit + \beta 2 \ln Iit + \beta 3 \ln \mathrm{Re}sit + \beta 4 Envirit + \varepsilon it \tag{6}$$

In (6), *q* represents the per capita real estate demand, and model (6) explains the impact of economic urbanization and spatial urbanization on per capita real estate demand. The change in per capita demand not only shows how improved residential demand is generated. It also reveals the root of the connotative development of the real estate market.

4.2 Variable Selection and Number Explanation

- Interpreted variables. In the analysis of the role of multidimensional urbanization on the real estate market, the focus is on the size of the real estate market, so the real estate market demand of each city is taken as the explanated variable;

in order to distinguish the different effects of multidimensional urbanization on different types of residential demand, the per capita real estate demand is taken as the explanated variable.

- Explanatory variables. The relevant indicators reflecting multidimensional urbanization are taken as explanatory variables, in which the level of urban per capita income and industrial structure reflect economic urbanization. The change of urban permanent population reflects the urbanization of population; Besides real estate development, the allocation of urban public resources such as fixed assets investment, medical care, culture and education reflects the spatial urbanization. Of course, housing prices are the most important explanatory variable affecting demand for real estate.
- Control variables. In this paper, the urban environment is controlled. Specific descriptions of variables and indicators are shown in Table 1.

Table 1 Description of the model variables

Nature	Name	Symbol	Definition
Explanated variable	Real estate demand	*Q*	Accumulated housing sales area in the year, in ten thousand squares
	Per capita real estate demand	*q*	Cumulative housing sales area/resident population, in square metres
Explanatory variable	Real estate price	*P*	Average selling price of house, yuan/m^2 (2005 constant price)
	Income level	*I*	Per capita income, based on urban per capita GDP (2005 constant price)
	Industrial structure	*Stru*	Tertiary industry GDP/Secondary industry GDP
	Population	*Pop*	City permanent population (ten thousand people)
	Public resources	*Res1*	Cultural education, counted by the number of college students (ten thousand)
		Res2	Medical and health care, number of hospitals (one)
		Res3	Fixed asset investment other than real estate development (100 million yuan, unchanged price in 2005)
Control variables	Environmental factors	*Envir*	The proportion of days in which air quality is better than secondary or higher in the whole year

Table 2 Descriptive statistics of variables

Indicator	Mean	Standard deviation	Minimum	Maximum
Q	1120.333	891.594	106.442	6257.146
q	1.36	0.595	0.323	3.418
p	7370.569	4831.205	2021.988	45146
I	61167.01	29098.28	12437	167411
Stru	1.2225	0.60986	0.474856	4.16526
Pop	841.726	572.969	144.68	3048
Res1	403948	231872.9	35987	1057281
Res2	318.026	251.217	49	1606
Res3	1751.522	1305.036	106.165	9024.443
Envir	80.868	16.216	13.42	100.3

- Data description. This paper chooses cities above the sub-provincial level except Lhasa as samples to analyze the annual data of each index in 35 large and medium-sized cities from 2006 to 2018. The data used in this paper are all from the Wind database. In order to eliminate the impact of price changes, price adjustments are made in all price-related indicators (housing price, per capita income, fixed assets investment, etc.). In order to eliminate the influence of index dimension and eliminate heteroscedasticity to the greatest extent, the logarithmic treatment was carried out for all indexes except environmental conditions.
- Descriptive statistics of variables. The descriptive statistics of the original values of each indicator are shown in Table 2. The data in the table faithfully reflects the multidimensional urbanization process and real estate market conditions of each city, which provides an objective basis for the analysis of the follow-up mechanism.

5 Results and Analysis

The empirical test and regression results of this paper are implemented by Stata14.0 software.

5.1 Unit Root Test

In order to avoid false regression, unit root test is carried out on all data before parameter estimation. Because short panel data is used, LLC method is adopted for the same root unit root test. If the null hypothesis of unit root is rejected, each sequence is stable. In the LLC test of panel data of all variables, the values of t statistics are all less than 0.05, indicating that the regression variables in the model are stable and can be used for regression fitting.

5.2 The Impact of Urbanization on the Demand of Real Estate Market

Using the model (5) to test the impact of economic, population and spatial urbanization on the real estate market demand, the results (see Table 3) show that per capita income level increased by 1%, real estate market demand increased by 0.798%; total population increased by 1%, real estate market demand increased 0.739%. The agglomeration of public resources and fixed asset investment other than real estate development increase the demand of real estate market. In short, multidimensional urbanization can promote the development of the real estate industry, among which the greatest contribution is the increase of income level and the increase of urban population. The above results have passed the significance test at different levels.

Table 3 The influence and result of multidimensional urbanization on the real estate market demand

Variable	lnQ			
	Economic urbanization	Population urbanization	Spatial urbanization	Multidimensional urbanization
lnp	0.0607	0.559***	0.168**	−0.0835
	(0.0983)	(0.0634)	(0.0721)	(0.104)
lnI	0.798***			0.378***
	(0.0832)			(0.112)
Stru	0.0362			0.0174
	(0.0608)			(0.0565)
lnPop		0.739***		0.312**
		(0.0967)		(0.136)
lnRes1			0.268***	0.197**
			(0.0832)	(0.0878)
lnRes2			0.241***	0.144
			(0.0799)	(0.101)
lnRes3			0.329***	0.217***
			(0.0447)	(0.0566)
Constant	−2.374***	−2.871***	−1.798***	−3.516***
	(0.514)	(0.598)	(0.889)	(1.063)
Observations	455	455	455	455
Number of cities	35	35	35	35

Note: ** and *** represent significance levels of 5% and 1%, respectively.

5.3 *The Impact of Urbanization on Per Capita Real Estate Demand*

Excluding the role of population change the model (6) examines the impact of economic and spatial urbanization on per capita real estate demand. The results (see Table 4) show that per capita income level increases by 1%, per capita real estate demand increases by 0.815%; investment in fixed assets outside real estate development increases by 1%, per capita real estate demand increases by 0.346%. The agglomeration of medical, health, culture and education resources has either insignificant or negative impact on the per capita real estate demand, which indicates that people care about the enjoyment of various public resources, but will not buy more real estate due to its dense distribution. Especially, the housing price around hospitals, schools and transportation hubs is generally higher. Among all the influencing factors, the increase of per capita income contributes most to per capita real estate demand. The effect of economic urbanization on the sustainable development of the real estate industry cannot be ignored, and the above results have all passed the significance test at different levels.

In the above two tests, the impact of price changes on real estate demand is negative, indicating that real estate demand shrinks due to the rise of house prices, but the degree of impact is different. For every 1% rise in house prices, market demand

Table 4 The influence and result of multidimensional urbanization on per capita real estate demand

Variable	lnq		
	Economic urbanization	Spatial urbanization	Multidimensional urbanization
lnp	−0.291***	−0.0181	−0.319***
	(0.0962)	(0.0757)	(0.0956)
lnI	0.815***		0.551***
	(0.083)		(0.110)
Stru	0.0285		0.0599
	(0.0567)		(0.0575)
lnRes1		0.100	0.0663
		(0.0874)	(0.0859)
lnRes2		−0.231***	−0.156*
		(0.0840)	(0.0845)
lnRes3		0.346***	0.181***
		(0.0470)	(0.0579)
Constant	−6.068***	−2.110**	−4.31***
	(0.508)	(0.934)	(1.08)
Observations	455	455	455
Number of cities	35	35	35

Note: *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

decreases by 0.0835%, and per capita demand decreases by 0.319%. It can be seen that the incremental effect of population urbanization at the present stage covers the crowding-out effect of house prices rise. In addition, the impact of environmental conditions on real estate demand is extremely low and insignificant, which is probably related to people's willingness to bear a certain degree of environmental deterioration in the process of urbanization. Moreover, in recent years, China has paid more and more attention to environmental protection, which in reality alleviates the worries of urbanization.

6 Conclusions and Suggestions

Through the above analysis, it can be seen that urbanization can increase the demand for real estate, but its influence mode and effect degree are different, among which the incremental effect of population urbanization and the income effect of economic urbanization contribute the most. Excluding the role of population urbanization, the increase of income level is the most important driving force for the increase of per capita real estate demand. Spatial urbanization reflected by public resource agglomeration and infrastructure improvement also has a positive effect on real estate demand.

In view of the above results, this paper puts forward the following Suggestions:

Pay attention to the supply and demand pattern of the real estate market determined by the characteristics of multi-dimensional urbanization, coordinate spatial urbanization with economic urbanization and population urbanization, and avoid the blindness of real estate development. Referring to the conditions $V_{su} = \sigma + (1 + \sigma)\, V_{pu}$ that should be satisfied in the process of population urbanization and spatial urbanization when living in equilibrium, the supply of urban real estate should be adjusted around the change of urban population, and the regulation and control of the results should be gradually transformed into the monitoring of the process, so as to prepare for the establishment of market-led real estate supply system and long-term mechanism of real estate.

In the context of population flow, the "war for talent" can directly promote the increase of urban real estate market demand, and promote the development of real estate industry in the short term, but the primary factor leading to the increase of per capita real estate demand is the increase of income level, so economic urbanization is the key to ensure the sustainable and healthy development of the real estate industry. Therefore, in order to maintain the sustained and healthy development of real estate market we should focus on urban economic growth, in addition to relying on population urbanization.

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Grey Correlation Analysis of Layer Medication Accident Triggering Factors Based on the Human Factors Analysis and Classification System

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Abstract Based on 187 safety drug use accidents recorded by 23 laying hen farming enterprises in China, the factors causing the accidents were systematically analyzed, and the human factors analysis and classification system (HFACS) suitable for laying hen farming industry was constructed. By using grey correlation analysis method, the factors causing drug use accidents were analyzed, and the importance of the factors causing drug use accidents in laying hens was determined by calculating the correlation degree between the factors.

Keywords Layer drug use accident · HFACS model · Grey correlation analysis · Correlation degree

1 Introduction

In the 1980s, poultry breeding started in China, and China had gradually become the first large-scale production of poultry in the world. Although the poultry industry effectively controls and eliminate certain diseases in keeping to the intensive development process, the disease caused huge losses in poultry industry due to the breeding characteristic "high density, small size, decentralized farming model, poor farming environment, lack of disease prevention and control ability and imperfect safety control system". According to incomplete statistics, there are nearly 80 types of nasty disease in the poultry industry at present. In China, varieties of poultry disease

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have caused the poultry mortality to 15–20% above and economic losses amounting to tens of billions of dollars each year [1].

At present, China's laying-hens industry shows a unique type of breeding (high density, small size, decentralized), so we try to control the veterinary drug residues and detection supervision. Most breeding enterprises or breeders are casual and not standardized in the feeding, disease control, medication, and other aspects, so they increase the risk of security of laying hens [2]. In the breeding process, veterinary medicine can not only prevent and treat animal diseases, but also can improve nutrition, promote the layer growing up, and increase production efficiency. It has become an important indispensable input in the production of the poultry industry. But if people do not properly use animal drugs, it will lead to serious results. Over the years, most of the reasons for the occurrence of the disease or accident are people's subjective mistakes or inadvertent small actions. The human is the principal in the breeding industry and human behavior goes through the whole process of feeding, so it is necessary to emphasize human factors when we study the layer.

Some farmers don't understand the pharmacological knowledge, repeatedly use similar drugs or use antagonistic drugs. For example, some farmers, in Tai'an city, Shandong province, switched to kanamycin when gentamicin is invalid after layers were ill. However, it not only had no obvious effect but also delay the disease. In fact, gentamicin and kanamycin both belong to aminoglycoside antibiotics, which are the same mechanism and resistance. And farmers use antagonistic drugs, causing that it greatly reduces the drug efficacy and increases the treatment cost. For example, some farmers mix β-lactamases with doxycycline to use causing the effect reducing. In addition, blindly medication also contributes the veterinary drug residues in layers and is not conducive to the growth and production of laying hens.

Most farmers have no medical professional knowledge and skills. In the process of dealing with disease, they can't suit the remedy to the case, according to the physiological characteristics of laying hens and the characteristics of drug dosage, resulting in drug poisoning or ineffective treatment. A farmer, in Laiwu, Shandong Province, added Ding ammonia kanamycin into the fodder when his layers got the respiratory illness. Because this drug is not easy to be absorbed in the intestine, the effect is very good. However, the drug has no obvious effect on systemic diseases and respiratory diseases due to the drug cannot be absorbed into the blood circulation. Different drugs, its function and the way of absorption are different. Choosing appropriate drugs based on a different disease to achieve immediate results.

In a medical accident, drug poisoning is common. Among them, the most common drug poisoning is maduramicin poisoning, sulfa drugs olaquindox poisoning, and other cold medicines. There are 30% toxin in almost drugs. The drug itself has strong toxicity, but the more important reason is the improper use of veterinary drugs. For example, in a large farm in Shandong Weifang, the breeder made a mistake, leading to dosage increased 10 times. Finally, because the cock was larger and the intake is also large, cocks almost died of poisoning in chicken place. What's worse, because the ratio of the male and female in the other farms is certain, it made the layer farm stop production in a long time with huge economic losses.

When the laying hens have a serious infection or mixed infection not be controlled, people need to take more than two kinds of antibacterial drugs in combination. There are only two kinds of drugs having an additive or synergistic effect to enhance the efficacy of drugs. Therefore, we must choose each other without the taboo of matching, two or more drugs having no antagonism effect. However, due to the lack of pharmacological knowledge or being anxious, some farmers or farms will randomly increase the drug dose or just put medicine mix that has different brand names but the same main components, which easily lead to drug poisoning. For example, a farm using own ingredients suspected coccidia infection, so they decided to add maduramicin in the feed. However, at the beginning of the ingredients in feed breeder forget maduramicin. To avoid punishment, the breeder secretly put all maduramicin to the last batch of feed, resulting in massive death of layers poisoning.

In recent years, many bacteria have been developed from single drug resistance to multi-drug resistance, and the degree of resistance and species of bacteria become more and more complex due to the wide use of antibiotics. What's more, the resistance genes of bacteria are transmitted among the populations of bacteria, the bacteria of the animal group and the ecological system, which make the resistance of the bacteria changed from acquired resistance to the generation of natural drug resistance in generations in life. The harm of antibiotic resistance is very serious: it causes the antibiotic treatment effect abusive, even causes the antibiotic to lose the curative effect. It will force the veterinary medicine to increase the dose due to the weakening of the therapeutic effect of antibiotics. This vicious circle makes the residual number of antibiotics increases in the eggs of these animal-derived foods, and thus leads to serious public health problems, and reduce the life of the drug market.

In 2001, on the basis of the Reason's Swiss Cheese, Scott and Douglas analyzed the data from the U.S. military and civil aviation and proposed the human factors analysis and classification system [3]. The model summaries the cause of the 4 levels of the accident proposed by Swiss Cheese, and defines each level. It is a system oriented human factors analysis method. At present, with air as the center, the HFACS has been widely used in the sea, railway, coal, nuclear power, and other fields [4–6]. However, such an excellent model has not been applied to agriculture, aquaculture. According to the characteristics of laying hens, and basing on the current experience in the field, this paper constructs the laying hen medication HFACS [7].

2 The HFACS of Laying Hen Safety Medication

Safe drug use accidents in laying hens are the result of the interaction of human, machine, environment and management factors. The traditional HFACS model mainly explores the causes of accidents from the perspective of human origin, while ignoring some other factors [8]. For example, the safety management system is not perfect, managers take inappropriate actions. In addition, because the model is based on aviation safety accidents, some accident factors are not applicable to the safety drug use accidents of laying hens, which is not consistent with the actual situation of the laying hen breeding industry [9]. Therefore, this paper improves traditional HFACS.

Based on the analysis and statistics of 187 safety drug use accidents recorded by 23 laying hen farming enterprises in China. According to the causes, this paper constructs a model of safe drug use for laying hens. The model includes four aspects: organizational influence, unsafe supervision, the precondition of unsafe behavior and unsafe behavior. Organizational influence includes organizational climate that refers to corporate culture, security awareness, honesty and trustworthiness, responsibility and other overall spiritual and cultural level factors, resource management that refers to the allocation and management of personnel, capital, equipment and production safety and skills training in the process of laying hens and emergency measures that can reduce or even save the loss if there are comprehensive emergency measures. In 2008, laying hens raised by a breeder in Jiangsu had diarrhea, anorexia, and egg production rate decreased. In the beginning, the breeders called two local veterinaries for help, but it's no improvement after treatment. In the absence of a definite diagnosis, the breeders had taken measures to break the water without food, at the same time consulted with the industry's best experts. Finally, it confirmed that moldy corn-induced incurred diarrhea, and timely treated hens. Thus, in the face of sudden illness, the emergency measures help the breeders to reduce the losses and solve the hidden dangers.

Unsafe supervision is divided into two aspects: government supervision and the problems not corrected timely. Eggs industry in China has been short of clear national standards and market access system in a long time. A lot of poultry breeders will violate compasses excessive use of antibiotics or nutrients to the pursuit of immediate interests, and promote the production. At the same time, the egg quality can only rely on instruments for identification, egg industry depends entirely on the free competition of the market in the absence of clear unified national standards and test supervision system is not perfect circumstances. In this situation, poultry breeders will inevitably use of illicit drugs to the pursuit of high output, high profits and reduce the production cost. In the process of feeding or medication, it is corrected or remedied in time after poultry breeders make mistakes, and it results in unnecessary losses. During treatment of laying hens, there will always be accidental or subjective violations, such as drug dose is not accurate, improper use of medication and so on. If mistakes are not corrected in time, ranging from lead to exacerbations, while in the large-scale deaths caused by flocks.

Preconditions of unsafe behavior include individual factors and environmental factors. Individual factors consist of professional quality and mental or physiological states. For a variety of reasons, the cultural quality of breeders is relatively low. Most of them at old age are primary, junior high, high school. Most poultry breeders have not received special technical training and think behind the concept. These factors will easily lead to the occurrence of a layer medication accident. Owing to lack of rest, high working intensity, or physical discomfort, and other reasons, poultry breeders may get stuck in mental fatigue, absent-minded, and careless and sloppy state, and these factors will affect poultry breeders making mistakes at feeding, medicine, and other situations, thus it leads to serious consequences. Environmental factors contain natural environment and breeding condition. The natural factors including clean water, good ventilation and plenty of sunshine are beneficial to laying hens growth and production. With environment changing, the surrounding environment of layer farm is easy to be pathogenic pollution. Pathogens from the surface of the earth, air, all kinds of vehicle comprehensive spread epidemic diseases, resulting in serious losses. As for breeding condition, some poultry breeders easily ignore the laying hens breeding environment when treat diseases. For example, the hen house space is narrow, dust is too much, feeder drinking fountains are not clean and so on. These factors not only provide a hotbed of breeding for the disease but also not conducive to cure disease.

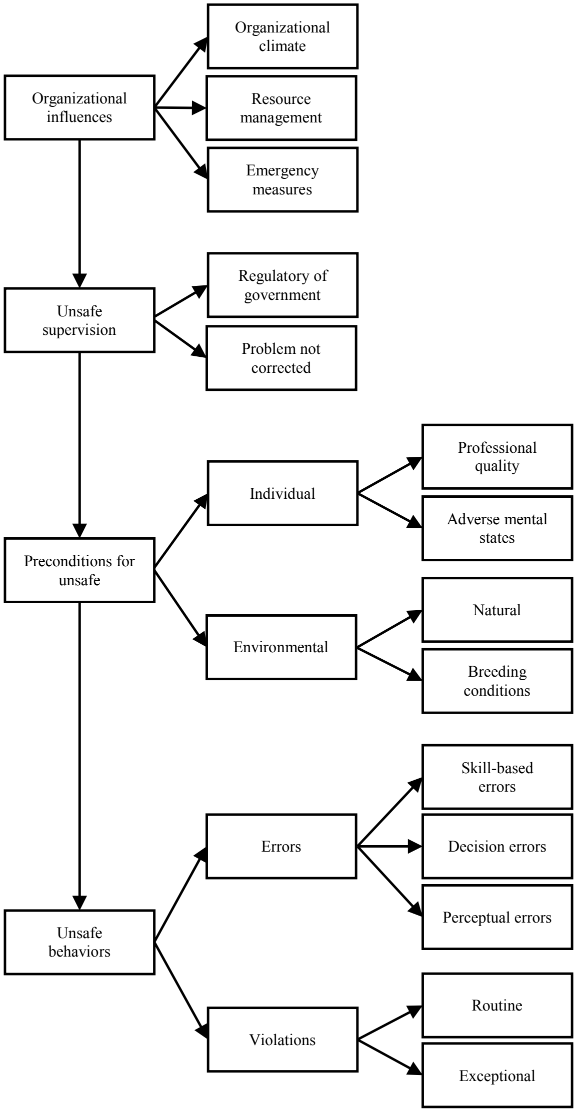
Unsafe behavior is divided into two aspects: error and violation. Errors include skilled-based errors that occur in breeding technology or treatment technical failure, decision errors that refer to that breeder dispenses drugs in accordance with the requirements of the company, but the drug is not suitable for the current disease layers are required and perceptual errors caused by improper cognitive mistakes including of knowing a little about pharmaceutical ingredients, efficacy or disease. Violations contain routine violations referring that conventional behavior is likely to lead to the occurrence of medical malpractice, while is often ignored and exceptional violations referring that the people in the process of layer medication have isolation, a typical behavior, of course, this kind of behavior is not eligible for management. The HFACS model is shown in Fig. 1.

3 Grey Correlation Analysis and HFACS

3.1 Grey Correlation Analysis

Grey correlation analysis is a systematic analysis method which describes the order and strength of the relationship among factors on the basis of grey theory [10–14]. It is also a multi-factor analysis method often used in the field of accident analysis. Grey correlation analysis regards individual data and whole data as a comparison sequence and the reference sequence. In essence, it can judge the similarity between individual data and whole data by describing the proximity between the two series curves. If the similarity between the comparison sequence and the reference sequence is high, the shape of the sequence curve will be similar, and the grey correlation degree between the two sequences will be high. On the contrary, if the similarity degree between the two sequences is low and the shape of the sequence curve is not similar, the grey correlation degree between the two sequences will be low. One of the advantages of grey correlation analysis is that there is no rigid requirement for the quantity and distribution of data in the application, and its analysis method is relatively simple. It is very suitable for the study of uncertain problems such as a small amount of data, insufficient information and no typical distribution law of data [15, 16].

Fig. 1 The HFACS of laying hen safety medication



3.2 Grey Correlation Analysis and HFACS

In this study, the grey correlation analysis method is used to process accident data to judge the HFACS model. At the same time, through the gray correlation analysis of the sub-factors of each level, the influence degree of each sub-factor on the level was judged. Combining the above two analysis results, the importance of human factors leading to accidents in the data reports of drug safety accidents for laying hens was ranked and judged.

In production, aquaculture enterprises need to consider many factors, such as economy, safety, reliability and so on. There are many factors affecting these factors, and it is difficult for aquaculture enterprises to fully grasp and analyze these factors. In addition, there are many and complex factors affecting safety in production and causing accidents, such as employees' awareness of safety in production and safety culture in enterprises, which are difficult to quantify. Even if the quantified factors are considered, their values may change due to the influence of other factors. Thus, quantitative factors may also be grey. In summary, among the many factors affecting the safe medication system of laying hens, some factors are not clear, the factors that have been identified cannot be quantified, and the factors that have been quantified are changed randomly. Therefore, the safety medication system of laying hens has typical grey characteristics, and it is a typical grey system with definite partial information and unclear partial information. Therefore, the grey system theory analysis method is the most reasonable way to analyze the causes of drug use accidents in laying hens. Grey correlation analysis method can be supplied to better quantitatively analyze the influence of various factors on the accident caused by drug use accidents in laying hens, which is conducive to putting forward more targeted accident prevention measures.

4 Method

4.1 Model Framework

As an important analysis method of grey system theory [17, 18], grey correlation degree analysis is a quantitative comparison of the changes of factors in the system or between different systems in the process of development with time, so as to get the correlation between factors [19, 20].

(1) *Determine the sequence of analysis.* In the analysis of the grey correlation degree of data, the reference sequence and comparison sequence should be determined first. Reference sequences consist of dependent variable data, usually denoted as $X_0 = \{X_0(1), X_0(2), X_0(3) \ldots, X_0(n)\}$ (n is the length of the reference sequence). The comparison sequence is composed of free variable data, which is usually recorded as $X_i = \{X_i(1), X_i(2), X_i(3) \ldots X_i(n)\}$, $i = 1, 2, 3 \ldots m$ (m is the length of the comparison sequence).

(2) *Standardized processing of raw data.* To ensure the analysis results' accuracy, it is necessary to normalize the original data, that is, the dimensionless variable sequence. The treatment method is as follows:

$$X_i(k) = \frac{X_i(k)}{X_i(1)} (\mathrm{k} = 1, 2, \ldots, \mathrm{n};\ i = 1, 2, \ldots \mathrm{m}) \tag{1}$$

(3) *The calculation of correlation coefficient.* The specific calculation methods are as follows:

$$\varepsilon(\mathrm{k}) = \frac{minmin|X_0(k) - X_i(k)| + \rho_{max}\max|X_0(k) - X_i(k)|}{|X_0(k) - X_i(k)| + \rho_{max}\max|X_0(k) - X_i(k)|}$$
$$(\mathrm{k} = 1, 2, \ldots, \mathrm{n};\ i = 1, 2 \ldots, \mathrm{m}) \tag{2}$$

Among them, ρ is resolution coefficient, and the value is usually 0.5 (0.1).

(4) *The calculation of correlation degree.* That is to say, the average value of each correlation coefficient is taken.

$$r_i = \frac{1}{n}\sum\nolimits_{k=1}^{n} \varepsilon(k) \tag{3}$$

(5) *Data collation. Sorting the correlations.* The larger the correlation degree is, the more consistent the trend of change between comparison sequence and a reference sequence is, that is, the greater the influence of comparison sequence on the reference sequence is.

4.2 Data Selection

The statistics of 187 drug safety accidents in 23 laying hen farming enterprises were made according to different influencing factors. The statistical results are shown in Table 1. Count number of accidents is X_0, organizational climate is X_1, resource management is X_2, emergency measures is X_3, the poor regulatory of the government is X_4, the problem not corrected timely is X_5, lack of professional quality is X_6, adverse mental or physiological states is X_7, natural environment is X_8, breeding condition is X_9, skilled-based errors is X_{10}, decision errors is X_{11}, perceptual errors is X_{12}, routine violation is X_{13}, exceptional violation is X_{14}.

Using grey correlation analysis method, the incidents of drug use accidents in laying hens of different grades were selected as the reference series, and the influencing factors were comparative series. The correlation degree was calculated by substitution (1)–(3).

Table 1 Influencing factors

Factor	Extraordinarily serious accidents	Serious accidents	Major accidents	Ordinary accidents
X_0	13	76	64	34
X_1	8	33	19	7
X_2	6	49	34	8
X_3	7	62	38	11
X_4	5	28	17	6
X_5	7	14	12	5
X_6	12	74	43	13
X_7	2	7	3	4
X_8	1	3	2	0
X_9	3	8	4	3
X_{10}	5	37	26	13
X_{11}	8	25	17	9
X_{12}	3	18	12	4
X_{13}	6	26	14	6
X_{14}	11	68	41	17

5 Results

The results have been described as follow:

5.1 Correlation Degree Analysis Between Drug Accidents and Causative Factors in Laying Hens

The correlation between drug use accidents and causative factors in laying hens was calculated. The results are shown in Table 2.

5.2 Correlation Degree Analysis Between Drug Use Accidents and Causative Factors Types in Laying Hens

The correlation between drug use accidents and the types of causative factors in laying hens was calculated. The results are shown in Table 3.

Table 2 The results of correlation

Factors	Correlation degree	Sorting	Factors	Correlation degree	Sorting
r_1	0.6255	11	r_2	0.7579	4
r_3	0.7201	6	r_4	0.6952	8
r_5	0.6956	7	r_6	0.6776	9
r_7	0.6256	10	r_8	0.6018	14
r_9	0.6185	13	r_{10}	0.8634	1
r_{11}	0.7597	3	r_{12}	0.7607	2
r_{13}	0.6207	12	r_{14}	0.7285	5

Table 3 The results of correlation

Code	Type	Correlation degree	Sorting
R_1	Organizational influences	0.6409	1
R_2	Unsafe supervision	0.5718	3
R_3	Preconditions for unsafe behaviors	0.5128	4
R_4	Unsafe behaviors	0.6085	2

Table 4 The results of correlation

Code	Factor	Correlation degree	Sorting
$R_{3.1}$	Individuals	0.6782	1
$R_{3.2}$	Environments	0.5414	2

5.3 Analysis of the Correlation Degree Between Individual Factors and Environmental Factors

The precondition of unsafe behavior is subdivided into individual factors and environmental factors. The correlation between them is calculated and the importance of both is analyzed. The results are shown in Table 4.

5.4 Analysis of the Correlation Degree Between Errors and Violations

Unsafe behavior is divided into error and violation. The correlation between them is calculated and the importance of the two is analyzed. The calculation results are shown in Table 5.

Table 5 The results of correlation

Code	Factor	Correlation degree	Sorting
$R_{4.1}$	Errors	0.8452	1
$R_{4.2}$	Violations	0.7031	2

6 Discussion

6.1 Conclusion

Human always makes error easily. Human's ability to perceive, analyze, and interpret information results in these errors. Existing literature has posited that faulty perception, unwarranted assumptions, and less communication lead to human's failure. HFACS model assists us to define human error's specific causes further. Moreover, systemic and individual errors should be identified by a system of error detection. The model can help us to identify and correct system problems but also hold individuals responsible for their acts.

Our research has several implications. First, skilled-based errors always result in adverse events as a primary factor. HFACS model analyses information about the specific human acts and the effect of systems on skilled-based errors. We found that the errors may be caused by workers who are lack of skills.

The second finding is a great deal of decision and errors, including perceptual errors, decision errors. It's not easy to the usual didactic training typically provided. In contrast, people can address these issues through simulation, reinforcement, and improvement strategies.

As for four causative factors, organizational influences and unsafe behaviors are the primary factors causing accidents, followed by unsafe supervision and preconditions for unsafe behaviors. Among the individual and environmental factors causing the accident, the individual factors have a more significant influence on the occurrence of drug use accidents in laying hens. In unsafe behavior, errors have a more significant impact on the occurrence of drug use accidents in laying hens.

6.2 Suggestion

In order to reduce the occurrence of drug use accidents in laying hens and the social impact of drug use accidents in laying hens, the following suggestions were put forward by calculating the correlation degree:

(1) Enterprises should strengthen safety management and improve safety supervision system. Over the years, most of the reasons for the occurrence of the disease or accident are people's subjective mistakes or inadvertent small actions. Thus, enterprises should pay attention to drug using management.

(2) Governments and enterprises can use administrative means, material or spiritual incentives to strengthen on-site supervision and inspection so that rewards and penalties can be clearly defined.
(3) Enterprise managers should strictly abide by national laws and regulations, play an exemplary role, improve their own safety quality, and strictly organize production and command in violation of regulations. In the process of dealing with disease, they should take the right ways to remedy according to the physiological characteristics of laying hens and the characteristics of drug dosage, to avoid drug poisoning or ineffective treatment.
(4) Enterprises should carry out all kinds of safety skills training to improve the safety awareness of employees and enhance their skills. Some employees don't understand the pharmacological knowledge, repeatedly use similar drugs or use antagonistic drugs. It results in the veterinary drug residues in layers and is not conducive to the growth and production of laying hens. Thus, it's important to improve the knowledge and skills of employees.
(5) Regularly inspect the management system of safe drug use in enterprises, timely revise and improve it according to the relevant regulations of the state and the actual production of enterprises, to ensure the feasibility and timeliness of the safety production management system. Different drugs, its function and the way of absorption are different. Choosing appropriate drugs based on the different disease to achieve immediate results.

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A Two-Phase and Integrated Multi-objective Approach for Operating Room Schedules

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Abstract Operating room (OR) is an important department in a hospital and the scheduling of surgeries in ORs is a challenging combinatorial optimization problem. In this paper, we address a problem of multiple resources allocation of ORs, and propose a surgery scheduling scheme of OR units. To solve this problem, a multi-phase and integrated multi-objective linear programming model is proposed. The first phase of the proposed model is a resource allocation model, which mainly focuses on the allocation of the ORs for each surgical specialty (SS). Based on the results of the first phase, the second phase is the cyclic Master Surgical Schedule (MSS) model, which aims to schedule the surgeries in each SS. The proposed models are solved by goal programming method, Analytic Hierarchy Process and ILOG CPLEX. Having compared the new schedule with the original schedule in the hospital, the results show that not only the utilization of the OR, the net profit and the number of surgeries scheduled increased significantly, but also the overtime of the OR decreased.

Keywords Operating room scheduling · Cycle scheduling · Multi-objective integer models · Goal programming

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1 Introduction

The operating room (OR) planning and scheduling is a notoriously complex and expensive process in terms of the procedures and resources involved [1]. That includes the determination of the operation time and the optimization of the allocation of various operation resources required by the ORs and various surgical specialties (SSs) in order to complete the whole operation process. The hospital managers usually try to meet conflicting goals such as OR utilization, efficiency, patient waiting, quality of care and quality of labor, while they realize that achieving everything is difficult, even sometimes impossible. This can explain why patients' waiting, uneven utilization and operations delay often occurs in the ORs. Therefore, the OR optimization of the hospital is an urgent problem for hospital administrators to solve [2]. Most OR scheduling decisions are simple strategies based on qualitative approaches, while in the past few decades, there has been a growing interest in quantitative approaches. Among them, the mathematical model and method of operations research are most commonly used. Below, we will introduce some of the key characteristics of OR planning and scheduling problems.

According to the above description of the OR schedule, it can be seen whether the OR arrangement is reasonable and whether the surgery of the entire hospital's surgical system can be performed normally. Based on the above background, optimizing the scheduling of the ORs for hospital administrators is an urgent need for them to solve.

The topic of this paper comes from a key project of the National Natural Science Foundation of China—Big Data Driven Smart Healthcare Management Innovation. In this paper, the Sect. 1 is the basic introduction of the research content, Sect. 2 the current situation of the research in the field of surgery scheduling at home and abroad will be discussed, the next Sect. 3 is the models of the OR schedule, Sect. 4 is a study to compare and verify the model, and Sect. 5 concluded the paper.

2 Literature Review

At present, the study of OR scheduling abroad is much more advanced than the domestic research, and has made a lot of achievements. Cardoen et al. reviewed the literature on recent surgical planning and scheduling, it is proposed that the uncertainty study in surgical scheduling will become one of the main directions of surgical scheduling development [1]. Blake et al. established an integer programming model to find the surgical schedule that suits the University Hospital of Toronto, Canada, which is to minimize the difference between the target assignment and the simulated assignment time [2]. Jebali et al. used mixed integer linear programming to model and analyze the surgical schedule [3]. Lebowitz used Monte Carlo simulation to evaluate and quantify the surgical sequence for patients' waiting time and operating room utilization [4]. Guinet and Chaabane proposed the original dual structural heuristic method to assign patient surgery dates and operating rooms [5]. Testi et al.

treat weekly surgical schedules as a three-stage process, and MSS is in the first two stages [6]. Shu and Luo used the mathematical model to consider the two-dimensional resource constraints of the operating room and the surgical assistant nurses, and set the target planning model to optimize the surgical scheduling with the goal of maximizing the utilization of the operating room [7].

In recent years, there were also some achievements on OR scheduling published one after another. Xiang, Yin and Chen have further increased the actual multiple constraints of nurse scheduling, and established the corresponding mathematical model of surgery scheduling [8]. Zhou and Yin proposed a distributed algorithm based on OR scheduling rules in order to improve hospital OR utilization and service quality while reducing the cost of OR [9]. Zhu, Zhang and Song constructed a scheduling model including the preparation time between the OR and the medical team [10]. It is verified that the scheduling model can effectively shorten the surgery completion time. Li and Jiang have adopted absolute robust optimizing strategy considering hospital cost and patient satisfaction. The optimizing model of surgery scheduling with uncertain surgery duration is constructed [11].

In these literature studies, most of the models are implemented on the basis of strong assumptions, which will not achieve long-term scheduling. Therefore, for these problems, this paper will adopt dynamic scheduling. At the same time, according to the actual needs, we propose a two-phase multi-objective dynamic OR scheduling, the first phase is the rolling resource allocation model, and the second phase is multi-objective dynamic OR scheduling.

3 Model Establishment

A reasonable OR scheduling scheme is designed to allow patients to undergo surgical treatment in the most effective time to avoid accidents. At the same time, this can also reduce the overtime hours of medical staff and improve the satisfaction of doctors.

However, the process of determining the OR scheduling program is very complicated. We must consider not only the medical staff and patients, but also the availability of the ORs, that is, the limitations of the OR resources. Therefore, this paper turns this problem into a multi-phase and multi-objective problem. According to the more effective idea of surgery resource schedule, the hospital surgery resource schedule is divided into two phases: the first phase is the surgery resource allocation model. The goal is to optimize the allocation of OR resources to each SS during the planning period. The second phase is the master surgery scheduling model. On the basis of the resources allocated to the OR in the previous phase, the specific surgery time and the OR are allocated for the scheduled surgeries of each SS, and the specific surgery schedule of each SS is worked out.

Before modeling, we made the following assumptions: (1) in this paper, the surgery time is transformed into the number of ORs to allocate; (2) this paper considers the use of the mixed public OR, all of which are of the same grade; (3) the requirements for the surgery to be performed in each SS are at the same phase of health or lower requirements for the phase of hygiene; (4) the duration of the surgery in this paper includes preoperative and postoperative time; (5) The OR is fully resourced before the surgery begins.

3.1 Operating Room Resource Allocation Model

In the hospital OR center, each SS reports the specific information of the patients under operated to the allocation center of the OR in a certain period of time. The allocation center allocates the ORs to each SS according to the demand based on the surgery time required by each SS.

When establishing the model, we first design the variables and parameters used in the model which are described in Table 1. The objective function of the mathematic model is described as following.

The objective Eq. (1) is to maximize the income of each SS and minimize the overtime cost when the allocated time cannot meet the demand of the SS. And the constraint (2) is that the total OR time allocated to each SS cannot exceed the total open time of the ORs. The constraint (3) ensures that the total ORs allocated to SSs can't exceed the ORs provided. The constraint (4) means that at least one OR should be allocated to each SS. The constraint (5) is that the total OR time allocated to each SS must meet the minimum requirements.

Table 1 Decision variable parameters

Symbol	Description
S	Set of surgical specialties
s	Index for surgical specialties in S
day	Scheduling period
OR	Set of operating rooms
time	Normal open hours per OR per day
overtime	Maximum overtime allowed per day per OR
RT	Total time required by each SS during the scheduling period
rt_s	The time required by the SS s during the scheduling period
$profit_s$	Surgical benefit per unit time of the SS s
$cost_s$	The overtime cost of the SS s
$alloc_s$	The number of ORs assigned to the SS s
$least_s$	The minimum OR time requirement for the SS s during the scheduling period

$$
\begin{aligned}
opt\ f(x) &= [f_1(x), f_2(x)] \\
&= \max \sum_{s=1}^{S} profit_s rt_s \\
&\quad \min \sum_{s=1}^{S} (rt_s - time * alloc_s * day) \cos t_s
\end{aligned} \tag{1}
$$

$$
\begin{aligned}
&\sum_{s=1}^{S} time * alloc_s * day \leq (time + overtime) * OR * day \\
&\forall s, s = 1, 2, \ldots, S
\end{aligned} \tag{2}
$$

$$
\sum_{s=1}^{S} alloc_s \leq OR \tag{3}
$$

$$
alloc_s \geq 1 \qquad \forall s, s = 1, 2, \ldots, S \tag{4}
$$

$$
time * alloc_s * day \geq least_s, \forall s, s = 1, 2, \cdots, S \tag{5}
$$

3.2 Multi-objective Dynamic Master Surgery Schedule Model

The cyclic schedule method in industry is used to arrange the surgeries in the SS among ORs, which is a kind of dynamic scheduling method. It refers to the way in which the production scheduling is carried out dynamically in one-time period after another as the schedule optimization time goes by. Cyclic scheduling can be carried out either on the basis of the original static scheduling or directly, and the ultimate goal is to get the optimal or sub-optimal scheduling within the current optimization area.

(1) *Step one*
This paper only considers elective surgeries, so each SS can know in advance the surgeries to be performed in the next period, and the doctors will mark the standard time and the deadline of the surgeries. These surgeries constitute the initial surgical pool-L_1.

(2) *Step two*
First of all, the scheme needs to pick out the surgeries from the initial surgery pool-L1 on the first day, and then arrange the suitable OR and surgical sequence for them. The process use integrated multi-objective model with four specific indicators [12] selected that is (1) the number of surgeries arranged every day; (2) the total OR overtime; (3) the total OR idle time; (4) and the equilibrium rate between ORs in order to select the surgeries and make the specific surgery schedule.

Before establishing the model, the variables and parameters used in the design model are described in Table 2. The mathematic model is described as the following:

$$
\begin{aligned}
opt\ f(x) &= [f_1(x), f_2(x), f_3(x)] \\
&= \max \sum_{i^s=1}^{I^s} \sum_{k=1}^{K} \sum_{n^k=1}^{N^k} arrange_{i^s k n^k} \\
&\quad \min \left(\sum_{i^s=1}^{I^s} \sum_{k=1}^{K} \sum_{n^k=1}^{N^k} arrange_{i^s k n^k} time_i^s - T_{normal} \right) \\
&\quad \min \left(T_{normal} - \sum_{i^s=1}^{I^s} \sum_{k=1}^{K} \sum_{n^k=1}^{N^k} arrange_{i^s k n^k} time_i^s \right) \\
&\quad \min \sum_{k=1}^{K} \left| \left(\sum_{i^s=1}^{I^s} arrange_{i^s k n^k} time_i^s - \frac{\sum_{i^s=1}^{I^s} arrange_{i^s k n^k} time_i^s}{K} \right) \right|
\end{aligned}
\tag{6}
$$

Table 2 Decision variable parameters

Symbol	Description
I^s	Set of surgeries in SS s
i^s	Index for surgery in I^s
K	Set of operation rooms
k	Index for operating room in K
N^k	The number of surgeries scheduled in the operating room k
n^k	The nth surgery in the operating room k
$time_i^s$	The duration of surgery i^s
dd_i^s	The deadline of surgery i^s
T_{normal}	The normal working hours of the operating room
$Topen_k$	The open hours of the operating room k for one day
$Tover$	The overtime in all operating rooms during the day
$Tover_k$	The overtime of the operating room k
Num	The total number of surgeries scheduled during the day
$arrange_{i^s k n^k} = \begin{cases} 1 \\ 0 \end{cases}$	If surgery i^s is selected and arranged in the nth order in OR k
	Otherwise

$$variable_{i^s} = \begin{cases} 1 \ when \ dd_i^s \leq 1 \\ 0 \ when \ dd_i^s > 1 \end{cases} \qquad \forall i^s, i^s = 1, 2, \ldots, I^s \tag{7}$$

$$\sum_{k=1}^{K} \sum_{n^k=1}^{N^k} arrange_{i^s k n^k} \geq variable_i \qquad \forall i^s, i^s = 1, 2, \ldots, I^s \tag{8}$$

$$\sum_{k=1}^{K} \sum_{n^k=1}^{N^k} arrange_{i^s k n^k} \leq 1 \qquad \forall i^s, i^s = 1, 2, \ldots, I^s \tag{9}$$

$$\sum_{\mathrm{i}^s=1}^{I^s} \sum_{n^k=1}^{N^k} arrange_{i^s k n^k} * time_i^s \leq Topen_k + Tover_k$$
$$\forall k, k = 1, 2, \ldots, K \tag{10}$$

$$\sum_{i^s=1}^{I^s} arrange_{i^s k n^k} \leq 1 \forall k, k = 1, 2, \ldots, K \, \forall n^k, n^k = 1, 2, \ldots, N^k \tag{11}$$

$$\sum_{i=1}^{I} arrange_{i^s k (n^k+1)} \leq \sum_{i^s=1}^{I^s} arrange_{i^s k n^k} \ \forall k, k = 1, 2, \ldots, K \quad \forall n^k, n^k = 1, 2, \ldots, N^k \tag{12}$$

The first objective function maximizes the number of scheduled patients in all operating rooms in a certain SS and the second one minimize the underutilization and overall overtime cost in the OR. The third one aims to balance between the ORs according to the standard deviation of the OR working time. Constraints (7) is the 0–1 variable. It seems that when the deadline is more than 1 day, the $variable_{i^s}$ equals to 0, otherwise, it's 1. Constraints (8) means that when the deadline for the surgery (latest completion time) is 1 day, the surgery must be completed on the same day. Constraint (9) prevents the surgery from being repeatedly arranged into the ORs. Constraint (10) indicates that the total time of surgeries scheduled in an OR cannot exceed the maximum OR open time. Constraint (11) ensures that at most one surgery can be performed in one OR at the same period of time. Constraint (12) assures that the next surgery can be performed only after the current one has been completed in an OR.

(3) *Step three*
When the surgeries are scheduled on the previous day, they will be removed from the surgery pool-L_1, the deadline of the unscheduled surgeries will reduce one day, that is $dd_i^s = dd_i^s - 1$. Therefore, the unselected surgeries form a new surgery pool-L_2. Through the above three steps of daily cycle, you can get a cyclic master surgery schedule.

4 Case Study

4.1 *A Case Study of the Operating Room Resource Allocation Model*

(1) *Data collection and solution*
The data used in this paper comes from a top three hospital in Beijing, which has 13 ORs for 9 different SSs. We first got the surgical data of the hospital's 9 SSs for one month, and set the scheduling period to 3 days, so we chose the surgery data for December 3–17, 2018, and then used ILOG CPLEX software to solve the established model. Results are as follows: ($x(s)$ equips to $alloc(s)$). $x(1) = 1$, $x(2) = 1$, $x(3) = 1$, $x(4) = 5$, $x(5) = 1$, $x(6) = 1$, $x(7) = 1$, $x(8) = 1$, $x(9) = 1$, where $x\ (s)$ is the number of ORs.

(2) *Comparison and analysis with the original allocation scheme in the hospital*
We obtained a new allocation scheme and compared it with the original one. From Table 3 and Fig. 1, we can see that the number of ORs assigned is consistent, but other indicators have changed. As shown in Fig. 1, the idle ratio, the over-load ratio and the over-loaded ratio decrease, while the OR operating efficiency increases after optimizing.

Table 3 Original and new allocation scheme

SS	OR time requirement (h)		Minimum OR time requirement (h)		Number of newly assigned ORs		New allocation time (h)	
	Original	New	Original	New	Original	New	Original	New
1	35	35	30	30	1	1	24	24
2	20	20	10	10	1	1	24	24
3	15	15	15	15	1	1	24	24
4	115	115	11	11	4	5	96	120
5	15	15	15	15	1	1	24	24
6	25	25	22	22	1	1	24	24
7	20	20	18	18	1	1	24	24
8	30	30	27	27	1	1	24	24
9	40	40	35	35	2	1	48	24
Total	315	315	282	282	13	13	312	312

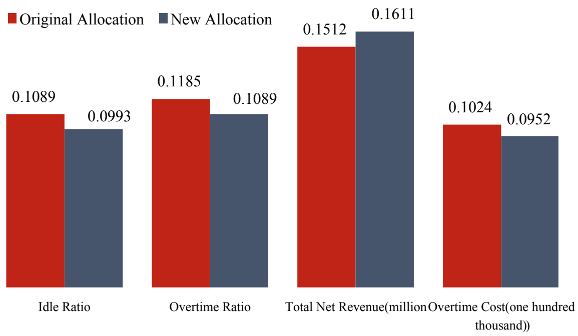

Fig. 1 Some indexes comparison in the original and new allocation

4.2 A Case Study of the Multi-objective Dynamic Master Surgery Scheduling Model

(1) *Solution*

We use AHP and goal programming to transform the multi-objective model of the second stage. Through the basic steps of the method, the obtained model is as follows.

$$\begin{cases} \min\{d_1^-\} \\ \sum_{i^s=1}^{I^s}\sum_{k=1}^{K}\sum_{n^k=1}^{N^k} arrange_{i^s k n^k} + d_1^- = Num \end{cases} \tag{13}$$

$$\begin{cases} \min\{d_2^+ + d_2^-\} \\ \sum_{i^s=1}^{I^s}\sum_{k=1}^{K}\sum_{n^k=1}^{N^k} arrange_{i^s k n^k} * time_i^s - T_{normal} + d_2^- - d_2^+ = 0 \end{cases} \tag{14}$$

$$\begin{cases} \min\{d_3^+ + d_3^-\} \\ T_{normal} - \sum_{i^s=1}^{I^s}\sum_{k=1}^{K}\sum_{n^k=1}^{N^k} arrange_{i^s k n^k} * time_i^s + d_3^- - d_3^+ = 0 \end{cases} \tag{15}$$

$$\begin{cases} \min\{d_4^+ + d_4^-\} \\ \sum_{i^s=1}^{I^s}\left|\left(\sum_{n^k=1}^{N^k} arrange_{i^s k n^k} * time_i^s - \frac{\sum_{k=1}^{K}\sum_{n^k=1}^{N^k} arrange_{i^s k n^k} * time_i^s}{K}\right)\right| + d_4^- - d_4^+ = 0 \end{cases} \tag{16}$$

$$minZ = P_1\left(d_1^+ + d_1^-\right) + P_2\left(d_2^+ + d_2^-\right) + P_3\left(d_3^+ + d_3^-\right) + P_4\left(d_4^+ + d_4^-\right) \tag{17}$$

where P_1, P_2, P_3, P_4 are the priority, and the order of precedence is evaluated. After that, the obtained data is used to solve the model by programming. The results are as follows:

$x(8, 1, 1) = 1, x(26, 1, 2) = 1, x(16, 1, 3) = 1; x(6, 2, 1) = 1, x(22, 2, 2) = 1, x(7, 2, 3) = 1; x(10, 3, 1) = 1, x(17, 3, 2) = 1, x(9, 3, 3) = 1; x(21, 4, 1) = 1, x(2, 4, 2) = 1, x(25, 5, 1) = 1, x(12, 5, 2) = 1, x(23, 5, 3) = 1$.

Similarly, the results the next day are as follows:

$x(3, 1, 1) = 1, x(31, 1, 2) = 1; x(30, 2, 1) = 1, x(15, 2, 2) = 1; x(18, 3, 1) = 1, x(29, 3, 2) = 1; x(21, 7, 4, 1) = 1; x(32, 5, 1) = 1, x(4, 5, 2) = 1$. Where $x\left(i^s, k, n^k\right)$ equips to $arrange_{i^s k n^k}$ that means that when $x\left(i^s, k, n^k\right)$ is 1, the surgery i is assigned, when it is 0, surgery i^s is not allocated.

(2) *Comparison and analysis between the new schedule and the original schedule in the hospital*
The results of the two-day calculations were collated, and the original and new OR scheduling results are shown in Tables 4 and 5. At the same time, we also use the Gantt chart to show the specific scheduling scheme in Figs. 2 and 3. Next, we will compare the two scenarios separately according to four different objectives.

Table 4 Original surgery arrangements in the SS

Time	OR	Surgery number	Deadline of surgery (days)	Duration of surgery (h)	Total surgery time (h)
Day 1	1	1	3	6.58	10.5
		2	6	3.92	
	2	3	7	4.8	9.5
		4	8	4.7	
	3	5	5	9.25	9.25
	4	6	7	3.15	7.49
		7	9	1.46	
		8	3	2.88	
Day 2	1	9	1	5.29	6.7
		10	9	0.41	
	2	11	5	7.33	10.73
		12	9	3.4	
	3	13	8	8.8	8.8
	4	14	8	5.13	8.63
		15	7	3.5	
		4	7	4.7	

Table 5 New surgery arrangements in the SS

Time	OR	Surgery number	Deadline of surgery (days)	Duration of surgery (h)	Total surgery time (h)
Day 1	1	8	3	2.88	7.91
		26	19	2.11	
		16	3	2.92	
	2	6	7	3.15	7.78
		22	5	3.17	
		7	9	1.46	
	3	10	9	0.41	7.87
		17	1	2.17	
		9	1	5.29	
	4	21	1	3.57	7.49
		2	6	3.92	
	5	25	16	2.75	7.93
		12	9	3.4	
		23	7	1.83	
Day 2	1	3	6	4.8	7.72
		31	3	2.92	
	2	30	6	3.8	7.3
		15	6	3.5	
	3	18	8	3.97	7.47
		29	5	3.5	
	4	27	4	7.91	7.91
	5	32	8	2.49	7.19

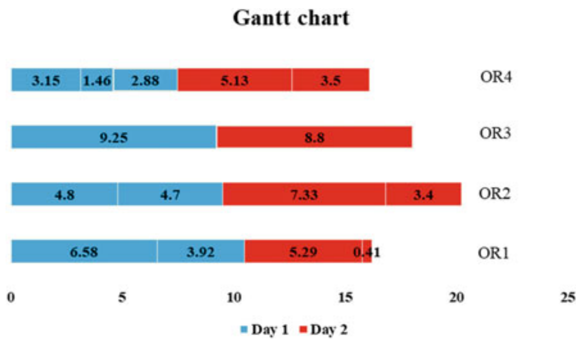

Fig. 2 Gantt chart in original scheduling

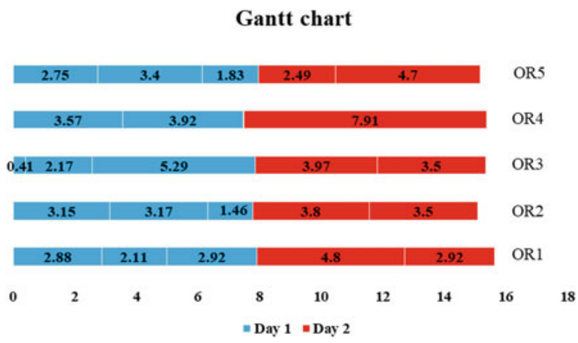

Fig. 3 Gantt chart in new scheduling

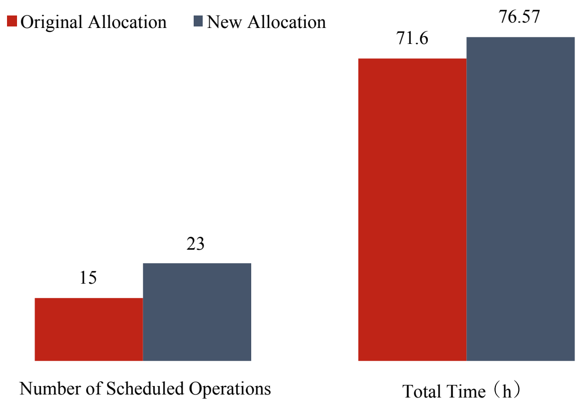

Fig. 4 Comparison of the number of surgeries and the total time

(a) *The first objective: comparison of the number of surgeries scheduled in two days*
First, we plotted the number of surgeries and the total surgical time of the two schemes in two days into the histogram of Fig. 4. As shown in the figure, the new scheme arranged 8 more surgeries than the original one, and the total surgical time was also added 4.97 h.

(b) *Objective two and three: comparison of overtime and idle time in ORs*
We compare the surgical time of each OR for one day with the standard working time of 8 h and show it in Fig. 5. We can find that in the original scheme, the total overtime is 9.41 h, and the idle time is 1.81 h. After optimization, there is no overtime, and the idle time is also reduced a lot, which achieves the basic optimization purposes.

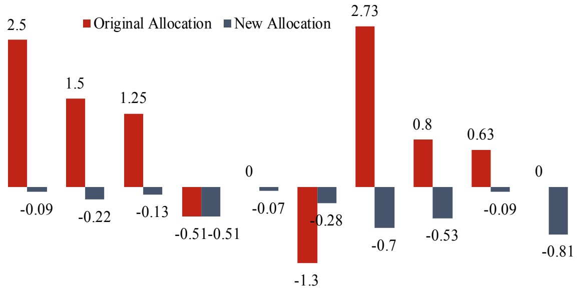

Fig. 5 Comparison of operating time and standard opening time

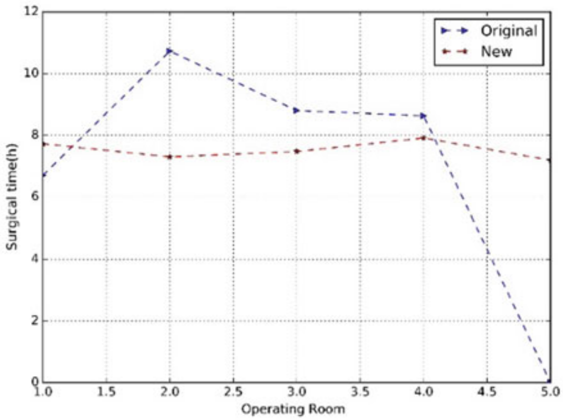

Fig. 6 Total time comparison chart of each OR (first day)

(c) *Objective 4: comparison of working time balance between ORs*
In order to achieve a balanced work in each OR, the fourth objective is to require the work time of each OR to be at the same as possible. It's measured by the standard deviation of OR working time.

And we compare that about quantitative and qualitative comparison analysis.

- Qualitative comparison analysis
  First of all, according to the total time before and after optimizing in two days, drawing Figs. 6 and 7. From the two, we can find that one part of the OR patients are very crowded, while the other part of the OR is idle, the service efficiency is not balanced, and it will inevitably cause the low overall service efficiency in the original scheme.
  While in the new scheme, the whole curve is relatively smooth, the utilization ratio between ORs is roughly the same, so there is no overtime, and the completion time between the ORs is basically balanced. The OR utilization rate and equilibrium rate were significantly improved.

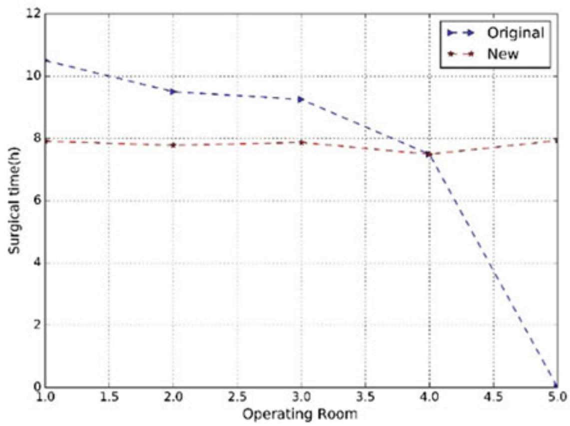

Fig. 7 Comparison of the total time of each OR (second day)

Table 6 OR time statistics (first day)

State	N	Minimum	Maxima	Mean	Standard deviation
Before optimizing	5	0.00	10.5	7.348	4.248443
After optimizing	5	7.78	7.93	7.796	0.180499

Table 7 OR time statistics (second day)

State	N	Minimum	Maxima	Mean	Standard deviation
Before optimizing	5	0.00	10.73	6.972	4.150177
After optimizing	5	7.19	7.91	7.518	0.296597

- Quantitative comparison analysis
  After the qualitative analysis was carried out through the line chart, then the OR working time before and after optimizing in two days was described and calculated by SPSS to carry out the quantitative analysis. The basic results are shown in Tables 6 and 7.

According to the results of description statistics, the standard deviations is 0.180499 and 0.296597 after optimizing which were obviously lower than those of 4.248443 and 4.150177 before optimizing. It can be concluded that the equilibrium rate between ORs is obviously increased, which reduces the cost of ORs, and the mean OR working time is closer to the standard OR opening time with 8 h, which is more in line with the reality.

5 Conclusion and Discussion

The key to effectively solving OR planning and scheduling problems is to balance surgical needs and available resources in an economical and effective way. To this end, we propose a multi-phase OR scheduling approach which addresses both tactical and operational decision levels, allowing updates to the waiting list status, availability of the ORs, and staff hours during the next planning period.

The devised OR resource allocation models and integrated multi-objective cyclic OR scheduling models yield a set of optimal decisions that aligns conflicting goals within SSs and related to hospital managers, and patients. On the basis of the OR time allocation finished, OR utilization balancing, maximization of scheduled elective surgeries by taking into account both reduction of OR underutilization and overtime and idle time costs: all these aspects have rarely considered to date at the same time. In fact, we have addressed, in an integrated way, OR time allocation, MSS construction, and surgeries scheduling problem by matching relevant specific requirements. In the process of solving the models, we put forward the GPA combined with AHP to accurately solve the MSS model, and compared the solution results with the actual OR schedule of the hospital, verifying the effectiveness of the models and solution approach.

To lay the foundation for further development of a more effective OR scheduling system, the optimization model and solution developed in this study can consider other resources (e.g., ICU, PACU and bed availability) as well as different goals for measuring performance.

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Detecting of Merger Waves in China's Capital Market

Ying Guo, Ming Xiao, and Ge Li

Abstract By taking all listed companies' mergers and acquisitions from 2007–2018 as a sample, this paper uses Harford's method to detect merger waves in China's capital market both at the industrial level and at the aggregate economic level. This paper also uses a Markov-switching model and intuitive method to test the robustness of these results. This study has concluded that, during the sample period, there are 1 wave at the aggregate economic level and 16 waves at the industrial level. The intensity of waves varies among industries. In addition, the clustering of industry merger waves in time leads to the occurrence of the aggregate wave to a certain extent.

Keywords Merger waves · Aggregate wave · Industry wave · Markova-switching model · Simulation

1 Introduction

Stigler said "The growth of individual firms to great size through M&A (merger and acquisition) with rivals is an outstanding phenomenon of modern economic history" [1]. Merger waves have in general been a topic of considerable interest in the academic and practical fields for decades. With China becoming the second largest economy in the world, the M&A activities in China's capital market have reached an unprecedented level in recent years. According to the data from IMAA (Institute for Mergers, Acquisitions, and Alliances), the total value of global mergers

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and acquisitions in the whole year of 2018 was $3896 billion, and the number of mergers and acquisitions was 50,052. Among them, China's total value of M&A transactions in 2018 is $635 billion, accounting for 16.30% of the global amount. Moreover, the number of M&A transactions was 7,638, account for 15.26% of the global deals. It displays that China plays a significant role in the world's M&A market and it is necessary to study China's merger waves. However, due to the development history of China's capital market is relatively short, the theoretical framework about merger waves has not been established.

Based on this, this paper studies the merger waves in China's capital market by taking the 7,510 M&A transactions of 2,447 listed companies in China from 2007 to 2018 as a sample. Firstly, we extend Harford's [2] method and use it to detect the number of merger waves and specific the starting and ending point of them. The results show that there are one aggregate wave and sixteen industry waves, and the intensity of the waves varies among industries. Then, we use the Markov-switching model to examine the dynamic trend of monthly merger activity for the aggregate level. In order to further test the robustness of these results, we also used Carow and Saxton' [3] intuitive method to stamp merger waves at the industrial level, and the results show that our research conclusions are reliable.

This study differs from earlier studies, which have considered mainly the United Regimes and European countries, as it focused on detecting merger waves in China's capital market. What is more, we expand Harford's method and apply MS-AR (1) (the first-order Markov-switching Autoregressive) model to detect merger waves. The results of this paper verify the hypothesis of China's merger wave, enrich the research theory of M&A activities, and provide a foundation for further studies about mergers and acquisitions.

The paper proceeds as follows. The next Sect. 2 briefly reviews the literature. Section 3 describes the data and empirical models. Section 4 presents the results of merger wave detecting. Section 5 concludes and discusses the future research directions.

2 Literature Review

Nelson described the concept of merger waves firstly, indicating that a period of very high activity is always followed by a period of lower activity [4]. Since then, western scholars have adopted a variety of methods to test merger wave, and generally agree that M&A activities are not random walks time series, but have periodic characteristics, thus proving the existence of merger waves. Merger wave refers to a phenomenon that the M&A transactions of a certain industry or economy gather in time and space. Western capital markets have long histories and have been coded several merger waves both in Europe and the US. Six merger waves at the aggregate level have been identified in the United States. They occurred in the 1990s, 1920s, 1960s, 1980s, 1990s, and early 2000s, respectively [5, 6]. The six waves were named as market consolidation, vertical integration, conglomerates, leveraged finance, internet bubble, and industry consolidation. However, in continental Europe and UK, only the last two and last three are acknowledged. In recent years, a lot of authors added a sixth wave which started in 2003 and ended in 2008 to this discussion and described it as the first global merger wave [5, 7–9].

In terms of the empirical methods of detecting merger wave in the existing literature, researchers have conducted a lot of researches. Shughart and Tollison argue that the number of M&A transactions followed a stable first-order autoregressive process and they believe this result means that merger waves do not exist but they do not provide any justification about their interpretation [10]. Golbe and White [11] respond to Shughart and Tollison' [10] claim by fitting a set of sine waves to the annual time series data on mergers and find that the sine curves generally provide significant explanatory power. This test is too inclusive. Many other time-series show dependence, however, most of them do not experience great waves like mergers and acquisitions data. Based on these two types of research, Town [12] applied the Markov-switching model which was proposed by Hamilton [13] into testing merger wave hypothesis firstly. This method was mainly used to test the dynamic developing trend of M&A deals of the aggregate economy. Although the Markov-switching model can test the merger wave hypothesis, it still can't answer how to determine the accurately starting and ending time of a wave, and if the industry waves exist, how to detect it. Harford's [2] method, which is widely used in wave related literature, is just enough to answer these questions. Harford identifies a merger wave by constructing an empirical distribution through 1000 simulations. This method has been used in many studies to detect industrial merger waves, such as Duchin and Schmidt [14], Xu [15], Fuad and Gaur [16]. The last class ways to confirm merger waves can be classified as intuitive methods. For example, Bouwman, Fuller and Nain [17] and McCarthy [9] defined a month as merger wave month if the resultant deal value is above the average of all months during the sample period, which the monthly deal value was corrected for inflation and removing the time-detrend. Carow and Saxton [3] and Xu [15] code a industrial merger wave by identifying a peak year in which the total number of M&A deals is the largest over the time period firstly, then, finding the start-year of a merger wave by moving forward from the peak year until the first year (t_1) in which the number of M&A deals less than 1/3 of the peak year, the following year ($t_1 + 1$) is identified as the start-year. The end-year of a merger wave is coded similarly. What is more, some researchers use the total number or total value of M&A activities as the proxy variable of merger wave directly.

Literature related to merger waves primarily focuses on the United Regimes and Europe and such literature on China is lack. All the empirical papers in Chinese mainly use the third and the last methods to detect merger waves. Taking mergers and acquisitions from January 1998 to January 2006 as an example, Tang [18] improves the merger wave hypothesis in China's Capital market by using a Markov-switching model with 3 regimes. In recent years, Liu, Sun and Pei [19] and Sun, Shao and Liu [20] test the dynamic trend of monthly M&A transactions by using Markov-switching model with 2 regimes. All of them find that there are 2 clear regimes in the history of M&A activities. There are some other domestic researches mentioned merger waves in their studies, but they didn't use rigorous econometric methods or just stay in the theoretical analysis stage. In addition to these articles in Chinese, we searched on Web of Science and found three empirical articles that mentioned China's merger waves. By taking China's beer industry as an example, the first one examines the correlation between competition structure and industry merger waves. But it directly describes the merger wave by using the number of M&A deals [21]. The second one focuses on the first global merger wave by following Bouwman, Fuller and Nain' intuitive methods in identifying merger waves [17]. It argues that China has been part of this wave and its performance was better than that of its Asian neighbors. But it does not directly detect China's merger wave [9]. Although the last one mentioned the merger wave of the ChiNext market in China, it examined the motivation of an enterprise's merger and acquisition actually [22].

In summary, there are very few papers studying China's merger waves. In addition to directly using the number and amount of M&A transactions as the proxy variable of merger wave, there is no study on detecting China's merger waves by adopting econometric methods, especially industry merger waves. Although the merger wave hypothesis has been verified, the number of merger waves and the starting and ending time of them haven't been identified. According to Corrao [23], merger waves at the industrial level often trigger merger waves at the aggregate economic level, so it is crucial to understand the merger waves at the industrial level. Therefore, this paper will use Harford's [2] method to detect the merger waves both at the aggregate level and industrial level. And we use Markov-switching model and intuitive method to test the robust of the results of aggregate economic wave and industry waves, respectively.

3 Sample Construction and Empirical Methods

3.1 Sample Construction

I start with all merger and acquisition deals recorded by Wind database between January 2007 and December 2018, and filter the empirical sample according to the following steps: (1) The transaction value should be at least ￥30 million. (2) Due to the industry focused on this thesis, only deals where the acquirer industry is available are included. Hence, the acquirer should be a domestic listed company. (3) Finally, only deals announced within the analysis period from 2007 to 2018 and have been completed are included. In total, we have 7510 deals in our main sample. In this paper, we adopted the 2012 CSRC industry classification standard. It is worth to mention that all the calculations in this paper are finished with STATA15.

The monthly total number of M&A transactions at the aggregate economic level are plotted in Fig. 1. As showed on it, a period of very high activity is always followed by a period of lower activity and there is a certain regularity in the M&A market. What is more, Fig. 1 shows that, mergers and acquisitions were fewer and less volatility before 2014. However, the number of M&A transactions jumped to a high level in March 2014. Until December 2017, the line showed two obvious peaks, which

Fig. 1 The monthly total number of M&A deals at the aggregate level

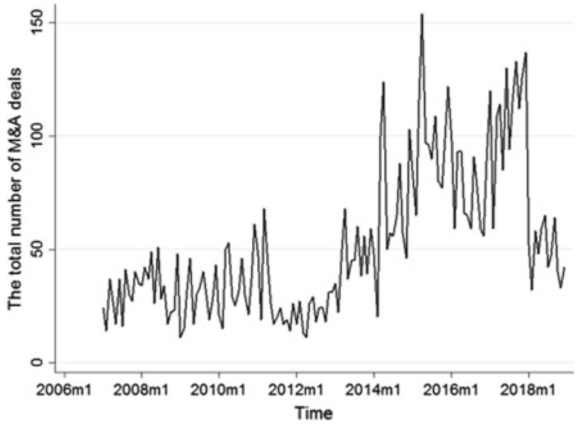
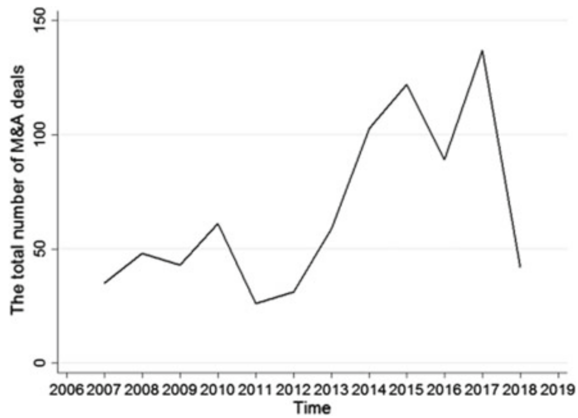


Fig. 2 The yearly number of M&A deals at the aggregate level



indicated preliminarily that there were merger waves in China's capital market. To get a better sense of this trend, we also plot the number of M&A transactions of each year across the economy (Fig. 2). Despite the trough occurred in 2016, the number of M&A remains at a high level compared with the years before 2014 as well.

These two figures show the temporal dynamic trajectory of mergers and acquisitions, but fail to depict the specific time when and how many merger waves occurred in China's capital market. Therefore, we continue to do the following research.

3.2 *Empirical Methods*

(1) *Harford's (2005) Method*
Harford [2] first detects a consecutive 24-month period as a potential wave firstly, where the concentration of M&A deals in each decade in that industry is

the highest, and then compare it with an empirical distribution. If the actual peak concentration of the potential wave exceeds the 95th percentile of the empirical distribution, then the potential wave is coded as a real wave. The empirical distribution is constructed by 1000 simulations. In each simulation, he randomly assigns each actual M&A deal to a month within the sample period, and get the highest 24-month concentration of M&A deals just as the potential wave. Harford [2] repeats this procedure 1,000 times and use the 1000 maximums to construct the empirical distribution. For instance, 1231 M&A deals occurred within a 24-month period starting in January of 2016 and ending in December 2017 in the Manufacturing industry(C), it accounts for 31.11% of the total deals in this industry. Out of 1000 simulations of 3957 real deals across our sample, over a 12-year period, the 95th percentile of maximum concentration within any 24-month period is 18.45%. Thus, the cluster of deals in the manufacturing industry starting in January of 2016 is coded as an industry wave. The advantage of this method is that it's relatively robust against outliers, as a single period with extremely high merger activity would not necessarily appear as a wave on its own. This model can be expressed as follows:

$$Y_{j,k+1} = \sum\nolimits_{i=1}^{24} x_{j,k+i} \quad (k \in [0, n-24], i \in [1, 24]) \tag{1}$$

$$Z_{j,k+1} = \frac{Y_{j,k+1}}{\sum\nolimits_{t=1}^{n} x_{j,t}} \tag{2}$$

$$max\left(Z_{j,k+1}\right) > P95_{Empirical\ Distribution} \tag{3}$$

where n is the total months included in the sample, in this study, it is 120. $x_{j,k+i}$ is the number of M&A deals announced in industry j in month $k+i$. $Y_{j,k+1}$ is thereby the sum of all deals announced in a 24 month window in a specific industry $Z_{j,k+1}$ is the concentration of the 24-month period.

The above model can detect at most one wave in each industry. But it is well-known that 1980s and 1990s were characterized by two distinct aggregate merger waves in the US capital market, with a substantial trough surrounding the 1990 to 1991 recession. With this fact, Harford [2] splits his sample into two sub-samples in advance, the 1980s and 1990s, so that he can capture two potential merger waves within each industry. But as for China's emerging capital market, while there is an intuition to merger waves, there is no clear consensus on the number of merger wave, as there is in the US. In this case, it is unreasonable to split the sample into sub-samples because we have not any basis. And it's inappropriate to limit the number of merger waves to one as well. Because it may lead to the omission of the objective merger waves which the concentration is equal to the peak simultaneously. Based on these considerations, we propose two other extensions to Harford's [2] method.

Firstly, we will not limit the sample detection period to a decade, but extend it to the entire study period, namely, from 2007 to 2018, a total of 12 years. Secondly, the potential merger wave will not be set to only one. We found that, during the history of M&A in China, the concentration of monthly M&A deals in several 24-month periods equals to the maximum simultaneously in some industries. So instead of only extracting the only one maximum 24-month concentration for each industry, we will compare all 24-month concentrations which equal to the maximum of the sample period to the 95th percentile of the empirical distribution and stamped them as merger waves if they exceeding the percentile. If several merger waves identified by this process overlap in time, they will be collectively coded as a complete wave in this paper. By adding these two modifications, the model allows us to detect several merger waves within a data set, while at the same time allowing for varying length of each merger wave.

(2) *MS-AR (1) Model*
Markov-switching model was proposed by Hamilton in 1989, Town [11] applied it to merger wave research firstly and was adopted by Linn and Zhu [24] yet. It is a nonlinear regime transformation model. Compared with other models, the most notable feature of this model is that the random process of transformation between different regimes is determined by an unobservable regime variable, which follows a Markov chain. MS-AR (1) model with two regimes is as follows:

$$y_t = \mu_{S_t} + \varnothing_{S_t} y_{t-1} + \varepsilon_t \tag{4}$$

In which y_t represents the number of M&A deals in time t, μ_{S_t} is the constant term in different regimes, ϕ_{S_t} is the coefficient of autoregression, S_t is the unobservable regime variable. ε_t is the error term. In this paper, we modified the homoscedasticity hypothesis in Hamilton's model. We assume that not only the AR coefficients are regime-dependent but also the variance parameters are regime-dependent. During the non-wave period, $S_t = 1$, $\varepsilon_t \sim N\left(0, \sigma_1^2\right)$. During the wave period, $S_t = 2$, $\varepsilon_t \sim N\left(0, \sigma_2^2\right)$. We assume that the regime variable S_t obeys the first-order Markov process in which the first-order transition probability is constant, that is, the probability of taking 1 or 2 at time t only depends on the regime at time t − 1 and has nothing to do with the regime before time t − 1. Assuming that p_{11} and p_{22} represent the probability of maintaining normal regime and wave regime respectively, namely $P(S_t = 2|S_{t-1} = 2) = p_{22}$, $P(S_t = 1|S_{t-1} = 2) = 1 - p_{22}$, $(S_t = 1|S_{t-1} = 1) = p_{11}$, $P(S_t = 2|S_{t-1} = 1) = 1 - p_{11}$.

P is the regime transition matrix:

$$\mathrm{P} = \begin{bmatrix} p_{11} & 1 - p_{11} \\ 1 - p_{22} & p_{22} \end{bmatrix} \tag{5}$$

An iterative method is used to calculate the probability ($\mathrm{Q_t}$) of wave regime and the probability of normal regime ($1 - \mathrm{Q_t}$) at time t respectively:

$$\begin{pmatrix} 1 - Q_t \\ Q_t \end{pmatrix} = \begin{bmatrix} p_{11} & 1 - p_{11} \\ 1 - p_{22} & p_{22} \end{bmatrix} \begin{pmatrix} 1 - Q_{t-1} \\ Q_t - 1 \end{pmatrix} \tag{6}$$

The estimation of above MS-AR (1) model is by maximum likelihood method. Firstly, calculate the joint probability density function L for $\{y_{1,}y_{2,} \cdots, y_T\}$: $L = \prod_{t=1}^{T} f(y_t)$.

$$f(y_t) = Q_t \frac{1}{\sqrt{2\pi}\sigma_2} \exp\left[-\frac{(y_{t-\mu_2} - \varnothing_2 y_{t-1)}^2}{2\sigma_2^2}\right] + (1 - Q_t)\frac{1}{\sqrt{2\pi}\sigma_1} exp\left[-\frac{(y_{t-\mu_1} - \varnothing_1 y_{t-1)}^2}{2\sigma_1^2}\right] \quad (7)$$

Next, estimate the parameters that make the likelihood function obtains the maximum:

$$max \prod\nolimits_{t=1t=1}^{T} f(y_t), \{p_{00}, p_{11}, Q_0, \mu_1, \mu_2, \varnothing_1, \varnothing_2, \sigma_1, \sigma_2\} \quad (8)$$

And then, iteratively calculated the probability ($\{Q_t\}_{t=1}^{t=T}$) of wave regime at each moment according to the iterative calculation formula and the estimated values of parameters. If $Q_t > 0.5$, t moment is deemed as wave regime. Lastly, test whether the residual is a white noise process and test the significance of parameters. If merger waves exist, the autoregressive process should have a bigger intercept or coefficient in wave regime. Following the above process, we detected the aggregate merger wave in China's capital market.

3.3 Intuitive Method

Carow and Saxton [3] code an industrial merger wave by identifying a peak year in which the total number of M&A deals is the largest over the time period firstly, then, finding the start-year of a merger wave by moving forward from the peak year until the first year(t_1) in which the number of M&A deals less than 1/3 of the peak year. And the following year ($t_1 + 1$) is identified as the start-year. Moving backward from the peak year until the first year(t_2) in which the number of M&A deals less than 1/3 of the peak year. And the prior year ($t_2 - 1$) is identified as the end-year. They start with all industries with 30 or more total acquisitions and then require there are at least 10 M&A transactions at least in 1 year. The peak year had to include at least three times as many deals as a 'trough' year to be considered a merger wave. Industries that do not exhibit a trend of significantly increased acquisition activity are excluded from further analysis.

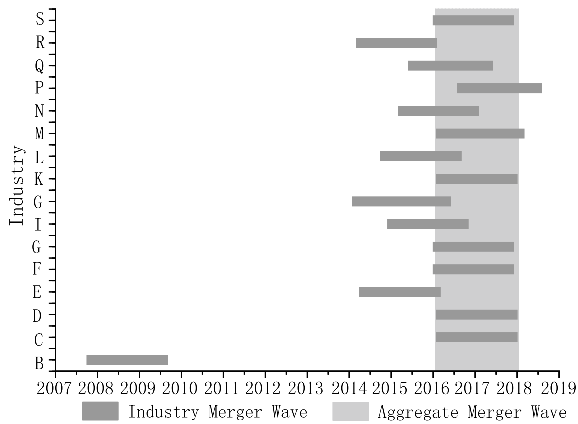
4 Results

4.1 Merger Waves in China's Capital Market

We used the extended Harford's [2] method to detect the merger waves at the aggregate economic level and industrial level. We found one aggregate wave and sixteen industry waves from sixteen industries (in addition to the (A) and the Accommodation and catering industry (H)), each of these industries has one wave during the period from 2007–2018. Although no industry has been detected two or more waves, the wave periods were extended in four industries because the potential waves are more than one and overlap each other. These industries are the Financial industry (J), Scientific research and technical services industry (M), Education industry (P), Health and social work industry (Q). The beginning and ending time of each wave was shown on it as well. In addition, the merger waves of the Manufacturing industry (C), Electricity, heat, gas and water production and supply industry (D) and Real estate industry (K) occurred between January 2016 and December 2017, overlapped the aggregate wave totally. The merger waves of Wholesale and retail industry (F), transportation, Warehousing and postal services industry (G), comprehensive industry (S) occur almost simultaneously with the aggregate wave as well, only one month ahead of it. Figure 3 also presents that the waves of construction industry (E), Information transformation, software and technology service industry (I), Leasing and business service industry (L), Water conservancy, environment and public facilities management industry (N) and Culture, sports and entertainment industry (R) occur between February 2014 to January 2017, earlier than the above waves. Although the periods of these industries waves are slightly different, all them occurred between 2014 and 2017, which is consistent with the period that with high M&A activities in Fig. 1 and Fig. 2.

However, the wave in the Mining (B) industry occurred from September 2007 to August 2009, far earlier than other industries. As the companies seek to further

Fig. 3 Merger waves in China's capital market



expand and stabilize the supply of minerals, the increase in demand for raw materials in emerging markets, as well as the growing capital competition in China, the integration of the mining industry occurred in a wide range. In fact, the global mining industry experienced an unprecedented period of change during this period, and this change was driven by mergers and acquisitions within the industry. According to Bloomberg's data, the mining industry has topped the list for the first time in 2008 since it conducted global M&A data statistics.

The statistic results of industries that have merger waves are described in Table 1. The second column reports the total number of M&A transactions of each industry, and the third column lists the number of M&A deals in merger wave. It shows that the intensities of merger waves are different across industries that have been identified merger waves, from 25.34% to 71.43%. The last two columns report the concentration of real merger activity in the 24-months period of industrial merger wave and the 95th percentile of the simulation distribution.

Since one wave can only be identified by Harford's definition of a window in which the concentration of M&A transactions reaches a maximum value and is greater than the 95% percentile of the simulated distribution, and the peak took place before 2011 is not obvious enough, only one aggregate wave of 24-month was detected

Table 1 The results of Harford's model

Industry	Number of M&A deals		The maximum concentration of 24-month	
	Total	In-Wave	Wave period (%)	The 95th percentile from the empirical distribution (%)
B	292	74	25.34	23.63
C	3957	1231	31.11	18.47
D	390	101	25.90	22.56
E	195	63	32.31	24.62
F	413	112	27.12	22.52
G	218	65	29.82	24.77
I	583	230	39.45	21.61
J	170	53	26.47	25.88
K	598	183	30.60	21.24
L	152	61	40.13	26.32
M	75	38	46.67	30.67
N	106	40	37.74	28.30
P	7	5	71.43	57.14
Q	49	27	55.10	34.69
R	158	58	36.71	25.95
S	65	21	32.31	27.69
Aggregate	7510	2240	29.83	17.98

even though we have relaxed the setting of wavelength. However, it can be seen the time of the overall wave coincides with that of most industry waves, indicating that our results are reasonable and the generation of the aggregate wave is affected by the clustering of industry waves.

4.2 Robust Tests

In order to further test the robustness of our detecting results of merger waves, we use the Markov-switching model and intuitive method to code the aggregate wave and industry wave again, separately.

(1) *Aggregate economic merger wave*
Based on prior literature, we use the MS-AR (1) model to investigate the dynamic changing trend of merger activities in China's capital market.

Table 2 presents the estimation results of MS-AR (1) model based on the maximum likelihood estimation method at the aggregate economic level. It can be seen there are clear differences in different regimes for mean parameters, autoregression coefficients and variances, which indicates that there are obvious two regimes in the dynamic process of M&A activities in China. The switching probability matrix shows that the probabilities of keeping in the original regime for regime 1 and regime 1 at t = 1, 2, ···, T, are high, 0.9916 and 0.9728, respectively. However, the probabilities of switching to another regime are very low, 0.0084 and 0.0272, respectively, which indicates that the stability of both the two regimes is higher.

The smoothed probability of the above MS-AR (1) model at $S_t = 1$ and $S_t = 2$ was plotted in Fig. 3 and Fig. 4, respectively, which depict the probability of regime switching of M&A activities at t = 1, 2, ···, T. As can be seen from Fig. 3, the history of M&A activities in China's capital market has indeed undergone a structural change. Before March 2014 and after January 2018, the M&A level was in the low regime ($P_r(S_t = 1|Q_t > 0.5)$), while from March 2014 to December 2017, the M&A

Table 2 Results of Markov-switching model

Parameter	Regime 1	Regime 2
μ	33.92*** (2.0678)	91.31*** (5.7041)
ϕ_i	0.34*** (0.0911)	0.35** (0.1450)
σ	13.41 (0.9652)	25.07 (2.6503)
Switching probability matrix	$P = \begin{bmatrix} 0.9916 & 0.0084 \\ 0.0272 & 0.9728 \end{bmatrix}$	
Log likelihood	−613.3332	

** and *** represent significance at the 5% and 1% level, respectively. The standard error is present in brackets activity is in the high regime ($P_r(S_t = 2|Q_t > 0.5)$). The turning point is 2014, which indicates there are merger wave in the capital market.

In addition, the period of regime 2 that have high merger activities presented in Fig. 5 overlaps the period of aggregate wave and industry merger waves presented in Fig. 3, which also shows that our results are robust and it's appropriate to detect China's merger waves using MS-AR (1).

(2) *Industry merger waves*
Following Carow and Saxton' study, we used the intuitive method to detect industry merger waves as well. Accommodation and catering industry (H) and Education industry (P) failed to enter the sample because the number of M&A transactions did not meet the sample selection criteria. Although the Mining industry (B) has more than 30 M&A deals and there are more than 10 deals in the peak year, but it still wasn't identified merger waves because of the small difference among the number of M&A transactions in each year. This

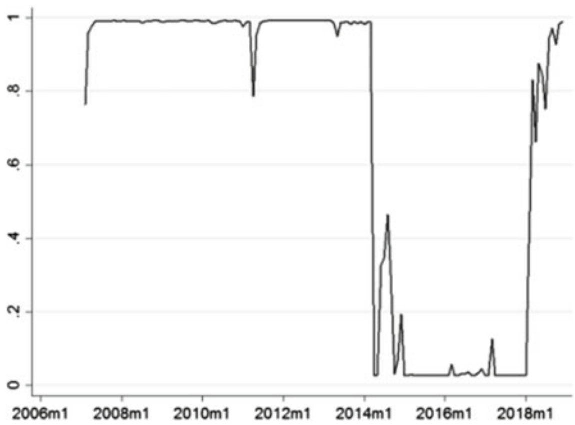


Fig. 4 Smoothed probabilities of regime 1

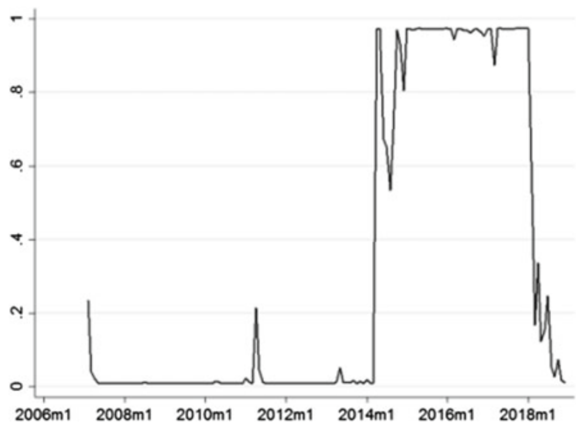


Fig. 5 Smoothed probabilities of regime 2

is just the difference between this intuitive method and Harford's method. The former requires a very high number of transactions in the peak year, in other words, confirms the outlier as a wave, but the latter calculates through the rolling window, requiring maximum transaction concentration of a 24-months greater than the empirical distribution, thus eliminating the impact of outliers. Despite these differences, as scientific methods that have been proved by extensive studies, these two methods' results of detecting the objective waves are generally consistent. Finally, we identified 17 industry merger waves from 15 industries (the Real estate industry (K) and Leasing and business service industry (L) have two distinct waves, one is near 2010 and one is after 2013). Except for the two earlier waves, the time period of all other waves is consistent with the results detecting by Harford's method and is just longer than the latter. It's mainly due to the standard of 1/3 in the definition of this intuitive method. The above results illustrate that our detecting results of industry merger waves by Harford's method is reliable. Due to space limitations, the detailed results are not reported in this paper.

5 Conclusions and Future Research Directions

In order to promote the development of M&A theory and empirical research in China, detecting merger waves, especially detecting industrial merger waves is very important. This study contributes to the existing literature by using the three main methods in the literature to detect the merger waves at the aggregate economic level and at the industrial level in China's capital market. Secondly, we extended Harford's method [2], and the results show that the model with no limit of potential wave number to 1 is more suitable for detecting China's merger wave.

Like any other research, this paper has its limitations. Although this study detects the merger wave and briefly discussed their motivations but does not do more tests on them. Exploring the cause of the wave is another huge area worth exploring. Future research can extend this study by exploring what drives merger waves, and investigate the relationship between the aggregate wave and industries waves. Researches can also test the influence of waves on the management decision making, such as cash holding, capital structure, corporate strategy and so on.

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Urban Roads and Urban Income Gap: Based on Data of 272 Cities in China

Xin Zan and Guoli Ou

Abstract Based on the data of one-percent national sample census carried by the Chinese National Bureau of Statistics (NBS) and 272 cities in China, we embark upon studying the effect and mechanism of the urban roads on the urban income gap, from the perspective of city scale and commuting costs, and further analyzing the heterogeneity of the influence from the Urban Roads on the cities. Theoretical study indicates that the positive effect of the urban roads on the urban income is smaller in the more developed or larger cities, whereas greater in those less-developed or smaller cities.

Keywords Urban roads · Urban income gap · City scale

1 Introduction and Literature Review

With the transportation networks in China improving rapidly and the passenger and freight transports orderly established, the migration of the production factors among different regions has become more efficient, showing the agglomeration trend, which promotes the rapid development of the regional economy. Meanwhile, it also creates more jobs, stimulates inflow of talents, and thus affects the distribution of the labor force together with the income level, resulting in the change of the development level and scale situation of the cities as stated in [1, 2]. The imbalance of the city income is aggravated and even the city polarization effect appears. As illustrated in Fig. 1, the visualization of the highway mileage in China and the Gini coefficient, we can

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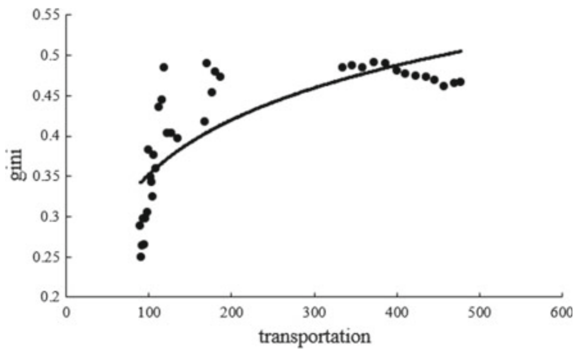

Fig. 1 Scatter plot of the national road mileage and Gini coefficient

observe that there exists some correlation between the traffic infrastructure and the income gap.

Some researchers have elaborated the influence of the traffic infrastructure on the income gap by comparisons between the urban and the rural, and also among different city clusters [3–5]. They focus on the industrial agglomeration, the economic growth, and the population mobility. For example, [6] also found that there is a spatial correlation between the expansion of the US high-speed railway and the change of the urban population via an empirical study. The new economic geography theory believes that the construction of the transportation infrastructure can reduce the transportation costs, accelerate the mobility ratio of the labor force, and also cause the spatial agglomeration of the industrial sectors, which in turn affects the size of the city. However, there is controversy in the study of the influence of the transportation infrastructure on the urban scale. For example, in [7], the authors believe that the well-constructed transportation infrastructure can effectively reduce the cost of interregional trades, and thus facilitating the transformation of some city clusters from the primary distribution to the rank-size distribution as in [7, 8]. The upgrading of transportation infrastructure will separate the primary city from the urban agglomeration [9]. Other scholars believe that the impact of transportation infrastructure on the city size is changing in stages. For example, in the panel data of China's typical urban agglomerations, [10] found that the transportation infrastructure gradually makes urban agglomerations transform towards a multi-center manner from a singlecenter manner. Such a gradual change presents an "inverted U shape". From the existing research, we can see that the transportation infrastructure contributes a certain evolutionary effect on the scale of the city by affecting the formation of the urban systems and their spatial forms [11]. Changes in the urban size will further affect the level and allocation of the urban income. In large-scale and densely-populated cities, the urban size is related to wages, wages are relatively higher [12]. Reference [5] found that when the city size gets doubled, the wages would increase by 4 to 8%. Under different city scales, the migration of labor force from the less developed cities to the more developed ones has intensified the competition within the cities. On the other hand, due to the wage increase of the migrant workers, the income gap with those non-migrant workers at the hometown is intensified, and thus the intra-city income gap is broadened [13]. In consideration of China's household registration system, the continuous development of the transportation infrastructure has prompted a large number of workers migrating into the cities from the rural areas, which further exacerbates the intracity income imbalance.

These studies mainly set forth on the traffic infrastructure, different industrial structures and the urban-rural income gap, with more emphasis on the regional economy increase and the urban-rural income gap, whereas lacking the concerns on the influence of the urban roads on the intra-city income gap and the mechanism in behind. As for the urban laborers, the urban roads plays an important role on their commuting behavior. The urban internal income gap has become a structural factor driving China's income gap, especially the inter-sectoral income gap and the inter-industry income gap are the most obvious. At the same time, the internal income gap of Chinese cities is mainly concentrated in the group, and the income gap between groups is small. From the perspective of the region, the construction of traffic road networks has certain influence on promoting the construction of the hub cities and economic belts [14]. The enhancement of reachability plays a significant role in shortening the commuting time and saving commuting costs for the residents. Due to the continual investment by the government on the infrastructure, the connections between different regions within the city are improved, and the mobility of the population is also enhanced [15]. When the city size expands to a certain extent and the labor commuting cost reduces to a certain extent, the excessive expansion of the urban population will lead it to the spatial spread, breaking the balanced distribution of the urban population and resulting in a deformed development. From the perspective of the traffic network, Braess described the contradictive phenomenon that the residents' commuting costs actually increases, namely the so-called "Braess paradox". In the expansion of the road network, it seems to make the situation even worse by adding a new route to ease the congestion [16].

Many scholars have also conducted further research on this basis. Reference [17] explored the deeper insights of Braess's paradox. From the Braess theory and its descendent research we can find that the travel choices of different residents will have different influence on others. The road conditions under different city scales have different effects on the commuting behaviors and job choices of urban residents, which will also have different effects on the income gap of urban residents as shown in [17, 18].

Most of the existing traffic infrastructure construction analysis of the income gap mechanism ignores the difference in urban internal income gap. The discussion on the construction of transportation infrastructure is mostly concentrated on the roads, railways and aviation between cities, and lacks relevant research on the internal roads of the city. Therefore, on the basis of the existing traffic infrastructure, the innovation of this paper is to further explore the impact of the urban roads on the income gap of urban residents income gap between cities. In the mechanism research, the city size variable was added to analyze the heterogeneity of the effect. It has an important role in promoting the influencing factors of income inequality within the city, and has certain reference significance for the rational construction of transportation infrastructure.

2 Theoretical Model

2.1 Urban Roads and Urban Residents Income Gap

Consider an economy involving both the urban and rural areas. There are only two industries in the economy, industry and agriculture. The industrial sector is located in the city, producing differentiated products. Every unit of product requires an investment of one unit labor. The agricultural sector is located in rural areas, producing differentiated agricultural products, which requires investments in land and labor. There is a large amount of homogeneous and mobile labor in the city, and enough land. The labor can flow freely between the urban and rural areas. This paper normalizes the labor force in the economy into one unit system. Denote the population in urban area as L_{urban}, then the population in the rural area is $1 - L_{urban}$.

Assuming that the interior of city expands along the x axis of the one dimensional space. The amount of the available land at each location $x \in X$ n the city is one unit, and all companies are located within the central business district (CBD) of the city. Each laborer needs to consume one unit of land to supply per unit of labor, and commute to the CBD every day. Therefore, at the equilibrium, the labor is evenly distributed within the interval $[0, L_{urban}]$ in the city. The village is located on the edge of the city (i.e., at $x = 0$). For the sake of analysis, the rural area is normalized to be a point located on the edge of the city, where the agricultural production is carried out. Assuming the CBD is located in the city, according to the assumptions made by Murata and Thisse, the commuting cost has the "iceberg cost" characteristic, and the effective labor provided by the labor force with the distance x to the CBD is affected by the commuting cost, which is stated as follows

$$s(x) = 1 - \theta x, x \in [0, L_{urban}], \tag{1}$$

To further describe the influencing factors of the urban commuting costs, for the sake of analysis, this paper assumes that there is only one transportation mode in the city, i.e., roads. Hence there are two factors that affect the commuting cost of the workers. The first influencing factor is the distance x to the commercial center in the city for work. As the distance x increases, the commuting cost of the workers goes higher. The second factor affecting the cost of commuting is the development level t of the road network. The development of the road network includes two aspects. One is the expansion of the coverage of the road network, which often leads to the growth of the city scale and increases the commuting cost. The other is the improvement of the coverage density of the road network. The road network is typically directed. One of its main features is the existence of network externalities, such as the traffic congestion, etc. It was usually assumed that the road added into the existing network is conductive to reducing the commuting costs of the workers. However, Brace found the contrary paradox that adding one or more roads into the traffic network will increase the commuting cost at the equilibrium, and the traffic network actually shows a social dilemma rather than getting enhancement as it seems

[18]. The study by Rapoport also reached the same conclusion that adding a path into the transportation network will lead to a 37% increase in the individual commuting cost on average [2]. The reason that the enhancement of the transportation network leads to the increase of the commuting costs is due to the selfishness of the individuals for choosing their own traveling routes [6]. Based on the above-mentioned research, the commuting distance and the development level of the road network positively affect the commuting cost of the workers. Hence we assume that the commuting cost has the following relationship with the traffic distance x and the road network development level t,

$$\theta = xt, 0 < \theta < 1.$$

Given the development level of the urban transportation network, the total labor supply of the city is

$$S_{urban} = \int_0^{Lurban} s(x)dx = L_{urban}\left(1 - \frac{L_{urban}^2 t}{3}\right). \tag{2}$$

For ease of analysis, we normalize the land rent at $x = L_r$ to be 0, so the net wage earned by the workers living at the edge of the city is

$$s(L_{urban})w_{urban} = (1 - L_{urban}xt)w_{urban}. \tag{3}$$

This article assumes that the workers are homogeneous, i.e., their wages are same in all the parts of the city after deducting the commuting costs and land rents, so there are the following equality

$$s(x)w_{urban} - R_{urban}(x) = s(L_{urban})w_{urban}, \tag{4}$$

where $R_{urban}(x)$ is the land rent at location x in city r, and w_{urban} is the urban wage rate. Therefore, in the case of a fixed distribution of workers, the urban land rent in equilibrium is

$$R_{urban}^*(x) = xt(L_{urban} - x)w_{urban}. \tag{5}$$

Based on (5), the total land rent of the city is

$$ALR_{urban} = \int_0^{L_{urban}} R_{urban}^*(x)dx = \frac{L_{urban}^3 w_{urban} t}{6}. \tag{6}$$

This paper assumes that the city has independent jurisdiction over the land and the land is equally owned by the whole labors in the city, and each labor receives an average income from his land ownership with $ALR_{urban}/L_{urban} = L_{urban}^2 w_{urban} t/6$.

Therefore, the disposable income of the urban labor is the sum of the wage and land rent

$$I_{urban} = \left(1 - x^2 t\right) + L_{urban}^2 w_{urban} t/6. \tag{7}$$

It can be seen from (7) that the disposable income of workers gradually increases from x = Lr to x = 0, hence the Lorenz curve in the city is

$$Y_{urban} = \frac{6 + 3L_{urban}^2 t}{6 - L_{urban}^2 t} p_{urban} + \frac{2L_{urban}^2 t}{6 - L_{urban}^2 t}\left(p_{urban}^3 - 3p_{urban}^2\right), \tag{8}$$

where $Y_{urban}, p_{urban}\left(0 < Y_{urban}, p_{urban} = \frac{L_{urban} - x}{L_{urban}} < 1\right)$ are the percentage of income and the percentage of the population below a certain disposable income level, respectively. Based on the above Lorentz curve, the Gini coefficient in the city is

$$G_{urban} = \left(2 - \frac{1}{3} L_{urban}^2 t\right)^{-1}. \tag{9}$$

Taking the first-order derivative with respect to the urban population and urban roads separately, we have

$$\frac{dG_{urban}}{dL_{urban}} = \frac{2}{3} t L_{urban}\left(2 - \frac{1}{3} L_{urban}^2 t\right)^{-2} > 0, \tag{10}$$

$$\frac{dG_{urban}}{dt} = \frac{1}{3} L_{urban}^2\left(2 - \frac{1}{3} L_{urban}^2 t\right)^{-2} > 0. \tag{11}$$

According to (10), the first-order derivative of the city's Gini coefficient with respect to the urban scale is greater than zero, indicating that as the size of the city expands, the Gini coefficient will increase in the city, i.e., the larger the city, the more unequal the income gap in the city. According to (11), the Gini coefficient has a first-order derivative greater than zero for highway development in the city, indicating that the improvement of highway development level will aggravate the unfair distribution of income within the city.

2.2 Urban Roads and City Scale

The study assumes that the labor consumption economy produces differentiated industrial and agricultural products. The products can flow between the urban and rural areas through transportation with the cost T, which is of the iceberg cost nature, i.e., there is loss of the production during transportation. The utility function of urban labor with CES form is as follows

$$U_{urban} = \left[\int\limits_{i \in \tau_{urban}} c_{uu}(i)^{\frac{\sigma-1}{\sigma}} di + \int\limits_{i \in \tau_{country}} c_{uc}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}. \tag{12}$$

The urban labor force uses all of its income for consumer products with the following budget constraint

$$\int\limits_{i \in \tau_{urban}} p_{urban} c_{uu}(i) di + \int\limits_{i \in \tau_{country}} p_{country} c_{uc}(i) di = I. \tag{13}$$

In the above formula, T_{urban} and $T_{country}$ are the collection of industrial products and agricultural products produced in the urban and rural areas, respectively. c_{uu} is the consumption of the industrial products produced in the city by the urban labors, and c_{uc} is the consumption of the agricultural products produced in the rural area by the urban labors. The consumption of each product can be obtained by optimizing the utility of the urban labor force under the above constraints,

$$c_{uu}(i) = p_{urban}(i)^{-\sigma} p_{urban}^{\sigma-1} I_{urban}, \tag{14}$$

$$c_{uc}(i) = p_{country}(i)^{-\sigma} T^{-\sigma} p_{urban}^{\sigma-1} I_{urban}, \tag{15}$$

where p_{urban} is the price index of the city, $p_{country}$ is the price index of the countryside, and the price index of the city has the following form

$$p_{urban} = \left[\int\limits_{i \in \tau_{urban}} p_{urban}(i)^{1-\sigma} di + \int\limits_{i \in \tau_{country}} c_{uc}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}. \tag{16}$$

Therefore, the indirect utility of the available urban labor is

$$V_{urban} = I_{urban} / p_{urban}. \tag{17}$$

As is mentioned above, the rural area is assumed to be located at the edge of the city and normalized as a point. Therefore the effect caused by population change in rural areas stays constant, and the marginal utility of the rural labor is denoted as *v*. The flow of the labor between the urban and rural areas depends mainly on its utility for the city and country. It always flows from the area with small utility to the area with large utility. Only when the last unit of labor enters the city and countryside, and its utilities are equal, the mobility of the labor flow will arrive at the equilibrium. Hence the workers' flow can be expressed by the following dynamic equation

$$\dot{L}_{urban} = \left(\frac{dV_{urban}}{dx} \Big|_{x=L_{urban}} - \bar{v} \right) L_{urban}. \tag{18}$$

When the population of two cities tends to be stable, $\dot{\mathrm{L}}_{\mathrm{urban}}$ is equal to zero, i.e. $\frac{dV_{urban}}{dx}|_{x=L_{urban}} = \tilde{v}$. According to (7) and (17), the urban population size at equilibrium is

$$L_{urban}^{*} = \frac{p_{urban}\bar{v}}{w_{urban}t}. \tag{19}$$

The first-order derivative of the urban road for (19) can be obtained

$$\frac{dL_{urban}^{*}}{dt} = \frac{p_{urban}\bar{v}}{w_{urban}t^{2}}. \tag{20}$$

The first-order derivative of the city scale with respect to the urban road level is greater than zero at equilibrium, indicating that the urban roads have a certain positive impact on the evolution of the urban scale. There are two main effects of the urban roads on the city scale, marginal effect and scale effect. As for the former effect, with the development of the urban roads, some network nodes develop into the transportation hubs which can attract talents, capital, and innovative technology to gather in large cities, thereby increasing the size of the city. As for the second effect, relevant research has found that the development of the urban roads will cause the spatially expansion of cities and further increase the urban population. Therefore, the following hypothetical relationship exists between the urban roads and urban scales.

Hypothesis 1: As the urban road construction progresses, the city scale expands.
Hypothesis 2: The impact of the city scale on the income gap of residents in cities is heterogeneous.

3 Research Design

3.1 Measurement Model and Variable Selection

This paper mainly explores the impact and mechanism of the urban roads on the urban income gap. By referring to the existing research literature [19], the urban income gap is loglinear with the city size. Assumption:

$$\ln(Cityineq_i) = \alpha \bullet \ln(Citysize_i) + \beta \bullet Road_i + X_i'\gamma + \varepsilon_i. \tag{21}$$

Equation (21) is a model to test the effect of the traffic infrastructure and city size on the urban income gap. The core explanatory variable is the logarithm of city scale and highway transportation infrastructure. “Road” is the core explanatory variable: road traffic infrastructure. For highway transportation infrastructures, we refer to the study of [20], using the highway density to measure the urban roads. The explained variable is the logarithm of the urban income gap [20]. The income of this study is measured by dividing the monthly income by the weekly working hours, which is a better measure for the per capita income of the urban residents compared to the weekly wages and monthly wages. If all workers work for the same length of time each week, or if the weekly average of the recorded working duration is the same, this measure will be closer to the theoretically estimated hourly wage for measuring the imbalance [21]. We use the Gini coefficient as an indicator of the income imbalance.

In (21), the control variable X is a column vector. Considering the influence of the missing variables in this study, we refer to the previous research and select the following variables as the control variables: the average education years of the city (Aeducation, year), the intensity of government fiscal expenditure (Governsupport, fiscal expenditure as a percentage of GDP), urban population density (Pintensity, population/square kilometers), per capita GDP (Pgdp, 10,000 yuan), the proportion of the employment in the secondary and tertiary industries (Secportion, thportion), average per capita wage (Awage, 10,000 yuan), the proportion of employees at the end of the year to the total population (Labor), the proportion of the urban private and individual employees and the employees in public organizations (Privatepub).

3.2 Data Source

The population data of this paper is from the 2005 National 1% Population Sample Survey Data. The data was sampled from 2,861 cities (counties) in China with a total population of 2.585 million people [22]. China carried out the household registration system in 2005, which divides the household registration into two categories: the so-called urban Hukou and the rural Hukou. Since our main population of observations is

Table 1 Summary statistics for some composition variables

Variable	Maximum	Minimum	Mean	Standard deviation
Cityineq	0.45	0.25	0.35	0.04
Thei	0.51	0.11	0.22	0.07
Population	3169.16	17.22	421.60	295.40
Pintensity	2661.54	4.72	412.27	333.3
Roadintensity	1.36	0.03	0.47	0.24
Gradeintensity	1.34	0.02	0.40	0.23
Aeducation	11.94	6.78	8.54	0.79
Secportion	76.69	12.00	41.68	13.55
Thportion	82.71	18.35	53.96	12.79
Governsupport	0.42	0.04	0.11	0.05
Pgdp	88562.0	2396.00	15165.06	12131.50
Awage	34327.7	6409.73	15401.08	4638.26
Labor	0.52	0.02	0.09	0.06
Privatepub	3.55	0.18	0.70	0.44

the urban residents, we have excluded the sample data corresponding to the residents of rural households when measuring the income inequality. The Gini coefficient is the main measure of the income inequality in this paper. The main age of urban population is 18–53 years old. Meanwhile, we merely considered the sample of those still having a job at the survey time. After eliminating the missing data, extreme data and rural household data, the number of sampled population is 389,000. The data like the urban road network density are cited from the China City Statistical Yearbook and China Statistical Yearbook. Table 1 shows the simple descriptive statistics for each variable.

4 Measurement Results and Analysis

The data used in this paper is the cross-section data of 272 cities. In order to eliminate the influence of heteroscedasticity on the parameter estimation, the heteroscedastic BP test is performed in all regression models. The results show that there is no heteroscedasticity in the data. The specific results are shown in Table 2. In addition, the fitting model of this paper has a good fitting effect, which can be known by the R2 and F tests of the following models.

Table 2 examines the impact of urban roads and city scale on the urban income gap. From model (1), it can be seen that the road network density has passed the test on the urban income gap by 5% with the coefficient 0.06, which means when the road network density increases by 1 unit, the urban internal income gap increases by 0.06%. After controlling the city scale, as shown in model (2), the test is passed at a significant level of 10%. It shows that the urban roads has a certain impact on the income gap. Model (3) also shows the impact of the city scale on the urban income gap. From the regression results, it can be seen that the impact of city size has not passed the significance test, but the coefficient is positive. In order to examine the actual impact from the road network density and the size of the city on the urban income gap, we add other control variables to the model. As shown in model (3), the impact of highway network density on the urban income gap is tested at a 5% significant level with a coefficient of 0.09, and the coefficient value is increased compared to the model (1) and model (2). This may be due to the existence of Bryce's paradox in the transportation network that the increase in the commuting time of some residents occupies their leisure time aggravates their lazy behavior during work, and further affects the work efficiency, leading to the rise of the unemployment rate and reduction of the income; while for some other residents, although it increases their commuting time, the probability of obtaining high-income jobs increases, and the possibility of increasing their net income also increases. Reference [18] research on the long-distance commuters found that more residents are willing to pay higher commuting costs, since long-distance commuting has a longterm positive impact, and besides offering a good living environment. In larger cities, some workers can work in the suburbs in the city, and they have a good living environment while partially raising their personal income. Other workers are limited by their income and education. Living on the edge of the city, the length of commuting time has aggravated the negative impact of separation of employment, which has led to a reduction in labor efficiency, and which is more likely to expose these workers to the risk of unemployment. Therefore, the increase in commuting costs caused by the urban roads development has led to a diversified urban income and an increase in the income gap.

Model (4) adds the interaction terms road network density and per capita GDP on top of the model (3). The regression results show that the adjustment term passes the significance test at the 10% significant level with the coefficient −0.04. It indicates that the per capita GDP has a negative adjustment effect for the impact of the road

Table 2 Regression analysis results

Model	(1) ln(Cityineq)	(2) ln(Cityineq)	(3) ln(Cityineq)	(4) ln(Cityineq)	(5) ln(Cityineq)
Roadintensity	0.06** (0.03)	0.06** (0.03)	0.09** (0.04)	0.15*** (0.05)	0.16*** (0.05)
Ln(population)		0.01 (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.06*** (0.02)
Ln(pintensity)			−0.02* (0.01)	−0.02 (0.012)	−0.03** (0.012)
Aeducation			−0.01 (0.01)	−0.01 (0.01)	−0.01 (0.01)
Secportion			−0.003*** (0.001)	−0.003*** (0.001)	−0.003*** (0.001)
Thportion			−0.003*** (0.001)	−0.003*** (0.001)	−0.003*** (0.001)
Governsupport			0.35** (0.17)	0.46*** (0.18)	0.39** (0.18)
Pgdp			−0.01 (0.01)	−0.01 (0.01)	−0.01 (0.01)
Awage			0.12*** (0.02)	−0.13*** (0.01)	0.12*** (0.02)
Labor			0.29 (0.18)	0.27 (0.18)	0.37*** (0.18)
Privatepub			0.02 (0.015)	0.02* (0.01)	0.02 (0.015)
Roadintensity × (population/10000)					−0.12 (0.06
Roadintensity × (pgdp)				−0.04* (0.02)	
Intercept	−1.09*** (0.02)	−1.12*** (0.06)	−1.08*** (0.12)	−1.13*** (0.12)	−1.20*** (0.13)
BP test (p-value)	0.99	0.99	0.87	0.65	0.07
Sample size	272	272	272	272	272
R^2	0.02	0.02	0.26	0.28	0.27
F test	4.55**	2.41*	8.42***	8.27***	8.11***

Note Levels of statistical significance are represented as follows: *** $p \leq 0.01$; ** $p \leq 0.05$; and * $p \leq 0.10$

network density on the urban income gap. This demonstrates that for cities with different development levels, the effect of transportation infrastructure on the urban income gap is different. The possible reason is that as the urban economic level improves, the proportion of workers tends to be stable who choose to reach the urban center but live on the edge of the city. The impact is weakened in which urban roads on the employment level of workers and job choices. Other Factors such as the level of education has become an important aspect affecting the income level of workers. Therefore, in cities with higher per capita GDP, the positive effect of urban roads on the income gap of urban residents is smaller than that of cities with lower per capita GDP.

Model (5) studies the heterogeneity impact of the urban roads on the urban income gap under different city scales. By observing the interaction coefficients between the city scale and highway density, it can be seen that it passes the test at the level of 10% significance, with the coefficient at -0.12. It indicates that when the other factors keep unchanged, the scale of the city has a negative adjustment effect on the impact of the road network density on the urban income gap. The results show that with the expansion of the city scale, the promotion of the urban roads to the urban income gap is gradually reduced. The possible reason is that with the gradual expansion of the city scale, the administrative area of the city tends to be stable, and the road network laying of larger cities tends to be perfect. The density of urban road network is no longer the income gap of urban residents. Important factors, the differences in capital conditions such as human capital and financial capital account for a large proportion of the income gap of urban residents, so the hypothesis is verified.

From the regression results of the other control variables, we can also see that the urban population density in the models (3), (4), (5) passed the test at the 1% significant level with the positive. This indicates that the increase in population density will aggravate the urban income gap. In cities with high population density, the absolute population is large, and the proportion gap is also large between the high-skilled and low-skilled people in the whole population, which increases the absolute value of the income gap inside the same city. The proportions of the employment passed the test at the significant level of 1% with the coefficient being negative in the secondary and tertiary industries. This indicates that various sectors of the national economy including mining, manufacturing, construction, commerce, and education services have contributed greatly to the improvement of the overall national economy. This manifests that the higher the proportion of the secondary and tertiary industries, the higher the per capita income, and the gap of wealth in the city is mitigated. The government expenditure intensity basically passed the test at the 5% level of significance, and the coefficient is positive. Basically, the government expenditure intensity passed the test at the 5% level of significance, besides, it also supports exacerbating the income gap within the city, that the per capita wages are more likely to promote in those departments that getting more financial support from the government. The specific regression results are shown in Table 2.

5 Conclusions

Focusing on the impact of the urban roads on the city size and the commuting cost, this paper uses the data of 1% population sampling survey and 272 cities in China in 2005 to explore the impact and mechanism of the urban roads on the urban income gap. The results show that:

- Urban road construction has a positive impact on the income gap within the city and has passed the test at a significant level of 5%. Under the conditions of controlling the size of the city, the education level of urban residents, government investment and other factors, urban road construction still exacerbates the urban income gap, and passes the test at a significant level of 5%, and the coefficient value becomes larger.
- The expansion of urban scale also has a positive impact on the urban income gap. In the case of controlling other factors, the test is passed at a significance level of 1%, and the coefficients are positive.
- In cities with higher per capita GDP levels and larger scales, the positive effect of urban roads on urban income disparity is smaller, while in cities with lower per capita GDP levels, urban roads promote formal income disparity. The effect is more obvious.
- In terms of the influence of other factors, the ratio of employment in the second and third industries is negative at the level of significance of 1%, indicating that the higher the proportion of employment in the second and tertiary industries, the urban internal income gap has a positive impact; the government's fiscal expenditure intensity has passed the test at a significant level of 5%, and the coefficient is positive, indicating that cities with higher government financial subsidies will have greater internal income gaps; Average wages passing the test at a level of 1% significance indicates that the per capita wage level has a greater impact on the income gap within the city.

Based on the above conclusions, in order to better promote urban road construction, this paper proposes the following policy recommendations:

- Under the rapid development of the urban roads construction, the orderly and effective operation of the transportation network should be further optimized, such as constructing of a convenient transportation network centered on the high-speed rail and expressway. At the same time, we should strengthen to leverage the role of economic radiation for improving the point-axis distribution and the radiate distribution within the city, aiming at further strengthening the intra/inter connection of the cities, so that the construction of the traffic network can really promote the rational flow of the factors.
- For the areas where the cities are relatively dispersedly distributed in scale and the level of the economic development is relatively low, it is better to make practical and feasible policies for them to raise the capability for offloading the population

from the larger cities, so as to boost their economic development momentum and improve their social service capability. This can help reduce the development gap between cities and facilitate their coordinated development in a stepped manner.

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The Influence of Agglomeration on Industrial Energy Efficiency

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Abstract This paper uses fixed-effects SFA (Stochastic Frontier Analysis) model to measure the total-factor energy efficiency of Chinese 34 industries during the period of 1998–2015 and then investigates the influence of industrial agglomeration on energy efficiency. It is found that industrial agglomeration has a negative effect on energy efficiency but it becomes smaller. Moreover, the energy consumption structure, measured by cola share, is negatively correlated with energy efficiency, and the ownership structure, measured by SOEs (state-owned enterprises) share, is proved to be negatively affecting the energy efficiency. These results suggest that the government should guide the industrial parks to reduce energy consumption with more strict environmental regulations, as well as switch to cleaner energy and deepen the reform of SOEs in the future.

Keywords Energy efficiency · Industrial agglomeration · Industrial economy

1 Introduction

Over the past 40 years of reform and opening up, China's economic development has made remarkable achievements and created a "Chinese miracle". At the same time, the industrial economy has also made unprecedented development and has become a "world factory" covering almost the entire industrial chain. However, economic growth has its inherent regularity. Since 2012, China's economic growth has been under great downward pressure and entered a "new normal" of medium and high-speed growth. The rapid growth of decades has also brought tremendous environmental pressure, resulting in frequent haze as well as various extreme weather and environmental degradation problems throughout the country in recent years, which is largely attributed to the traditional extensive growth mode. Meanwhile, the issue of global warming has also made energy saving and emission reduction become the consensus of the international community. Therefore, how to get rid of the "three

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high" problems of "high input, high consumption and high emissions" and realize the thorough transformation of the mode of industrial economic growth has become one of the core issues of sustainable economic growth in the new era.

In this context, this paper aims to investigate the energy efficiency of Chinese industrial sector and explore its determinants. Considering the current characteristics of industrial parks as the carrier of Chinese industrial development, this paper will focus on the impact of energy efficiency of agglomeration.

This paper follows the concept of total-factor energy efficiency (TFEE) that was first defined as the ratio of the target energy input to actual energy input in the data envelopment approach (DEA) framework by Hu and Wang [1]. However, traditional DEA models treat the deviation from frontier as inefficiency, while SFA models take it as inefficiency as well as stochastic noises, which is more theoretically appropriate. Moreover, due to the excellent work of Zhou et al. [2] that utilized the Shephard energy distance function to capture the maximum energy reduction potential, the strand of SFA-TFEE studies has become popular. For example, Honma and Hu [3] added environmental variables to the SFA model and estimated TFEE scores of Japanese 47 regions during 1996–2008. Du and Lin [4] used the fixed-effects SFA model to estimate the Malmquist energy productivity change of the world's 123 economies between 1990 and 2010.

On the other hand, many studies paid attention to the influencing factors of TFEE [5–7]. Recently, Tanaka and Managi [8] explored the effect of industrial agglomeration as well as oil price on the (relative) TFEE based on plant level data in Japan's paper/pulp industry and cement industry. Zheng and Lin [9] also focused on the effect of industrial agglomeration on TFEE using the panel threshold model in paper industry. Different from the above studies, this paper aims to explore the influence of agglomeration on TFEE among Chinese 34 industries. First, we apply the fixed-effects SFA technique to calculate TFEE scores rather than DEA or normal SFA techniques. Second, most similar studies have focused on the region-level, while this paper choose the rarely used industry-level.

2 Methodology

2.1 TFEE with Shephard Energy Distance Function

Suppose a neoclassical production economy, in which capital (K), labor (L) and energy (E) are taken as inputs to produce output (Y). The production technology is defined as:

$$P = \{(K, L, E, Y)|(K, L, E) \text{ can produce } Y\} \quad (1)$$

Referring to Zhou et al. [2], the Shephard energy distance function is defined as follows:

$$D_E(K, L, E, Y) = \sup\{\rho|(K, L, E/\rho, Y) \in P\} \tag{2}$$

In Eq. (2), ρ reflects the maximum potential of energy conversation when keeping the rest input-output variables unchanged. Thus, the TFEE can be described as:

$$TFEE = 1/D_E(K, L, E, Y) \tag{3}$$

We utilize a translog function to describe the Shephard energy distance function following Du and Lin [4] with fixed-effects:

$$\begin{aligned}\ln D_E^t(K, L, E, Y) = {} & \beta_i + \beta_K \ln K_t^i + \beta_L \ln L_t^i + \beta_E \ln E_t^i \\ & + \beta_Y \ln Y_t^i + \beta_{KK}\left(\ln K_t^i\right)^2 + \beta_{LL}\left(\ln L_t^i\right)^2 \\ & + \beta_{EE}\left(\ln E_t^i\right)^2 + \beta_{YY}\left(\ln Y_t^i\right)^2 + \beta_{KL} \ln K_t^i \ln L_t^i \\ & + \beta_{KE} \ln K_t^i \ln E_t^i + \beta_{KY} \ln K_t^i \ln Y_t^i \\ & + \beta_{LE} \ln L_t^i \ln E_t^i + \beta_{LY} \ln L_t^i \ln Y_t^i \\ & + \beta_{EY} \ln E_t^i \ln Y_t^i + v_t^i\end{aligned} \tag{4}$$

where $\ln D_E^t(K, L, E, Y)$ denotes energy inefficiency; v_t^i is a random variable accounting for statistical noises and assumed to be i.i.d $N\left(0, \sigma_v^2\right)$; β_i refers to time invariant unobserved individual heterogeneity. According to (2), the Shephard energy distance function is linearly homogeneous in energy, thus we can rewrite Eq. (4) as:

$$\begin{gathered}\ln\left(1/E_t^i\right) = \beta_i + \beta_K \ln K_t^i + \beta_L \ln L_t^i + \beta_Y \ln Y_t^i \\ + \beta_{KK}\left(\ln K_t^i\right)^2 + \beta_{LL}\left(\ln L_t^i\right)^2 + \beta_{YY}\left(\ln Y_t^i\right)^2 + \beta_{KL} \ln K_t^i \ln L_t^i \\ + \beta_{KY} \ln K_t^i \ln Y_t^i + \beta_{LY} \ln L_t^i \ln Y_t^i + \varepsilon_t^i\end{gathered} \tag{5}$$

where $\varepsilon_t^i = v_t^i - u_t^i$, denoting composite error; $u_t^i = \ln D_E^t(K, L, E, Y)$ is assumed to be independent of v_t^i and follows a distribution of $N^+\left(0, \sigma_u^2\right)$. Thus, Eq. (5) can be estimated by the so-called fixed-effects SFA techniques. We follow the Maximum Likelihood Dummy Variable (MLDV) approach introduced by Greene [10].

2.2 Econometric Model and Data Description

With reference to the related studies, the econometric model is formulated as:

$$TFEE_t^i = \alpha_i + \delta IA_t^i + \gamma X_t^i + \eta_t^i \tag{6}$$

where α_i and η_t^i denote individual effects and error term, respectively. IA represents industrial agglomeration; the matrix X_t^i contains the other independent variables that affect the TFEE.

- Industrial agglomeration (IA). Many empirical studies have illustrated the relationship between agglomeration and productivity to be positive or negative [11, 12]. As for the measurement of agglomeration, we construct the locational concentration index of each sub-industry, that is, CR_n.

$$CR_n = \sum_{j=1}^{n} x_j / \sum_{j=1}^{N} x_j \tag{7}$$

  where j represents province, and x_j represents the sale revenue of province j. N denotes all the provinces and n denotes the top provinces in terms of sale revenue. In literature, CR_4 is commonly used and ranged from 0 to 1. Data are collected from various provincial yearbooks as well as the *China Industry Economy Statistical Yearbook*. In addition, the quadratic term will be added in the analysis to reflect the nonlinear relationship.
- Energy consumption structure (ECS). Compared to other fuels, coal is less efficient. Therefore, the industry with bigger share of coal is less energy efficient. We use the share of coal to total final energy consumption to denote ECS, and the data are collected from *China Energy Statistical Yearbook*.
- Ownership structure (OS). It has been discussed that the state-owned enterprises (SOEs) is inefficient compared to private-owned enterprises due to its soft budget constraint [13]. Meanwhile, a number of studies have demonstrated that ownership structure significantly influenced energy efficiency/productivity [14, 15]. We use the share of SOEs' sales revenue to all sales revenue to measure OS, and the data are from *China Industry Economy Statistical Yearbook.*

In the empirical study, we consider the sample period of 1998–2015. Output (Y) is measured by industrial gross output value. Labor (L) is measured by the number of employees. We use the final energy consumption to measure energy (E). For capital stock (K), we apply the perpetual inventory method to estimate as $K_t^i = \left(1 - \delta_t^i\right) K_{t-1}^i + I_t^i$, where K_t^i, δ_t^i and I_t^i are the capital stock, depreciation rate and new investment of industry i at period t, respectively. Further, the new investment $\left(I_t^i\right)$ is calculated by the difference of the original value of fixed assets, and the depreciation rate $\left(\delta_t^i\right)$ is computed by the ratio of current depreciation value to the original value of fixed assets. Data of Y, L, E, K before 2009 are acquired from Chen [16] and the others are extrapolated following Chen's methodology. The raw data of the above variables are collected from *China Statistical Yearbook*, *China Industry Economy Statistical Yearbook* and *China Energy Statistical Yearbook*, and the nominal data are deflated into constant price at 1990.

Additionally, the National Standard of Industrial Classification has been amended several times. To ensure the consistent statistical coverage of industrial sector, we finally select 34 sub-industries that are almost unchanged and make some necessary adjustments. Table 1 lists the Chinese 34 sub-industries used in the empirical analysis. Table 2 provides the description of related variables.

Table 1 The code and abbreviation for each sub-industry

Code	Industry	Code	Industry
S01	Coal mining and washing	S18	Chemical materials and products
S02	Oil and natural gas extracting	S19	Medicines manufacturing
S03	Ferrous metal mining	S20	Chemical fibers manufacturing
S04	Non-ferrous metal mining	S21	Rubber and plastics manufacturing
S05	Non-metal mining	S22	Non-metallic mineral products
S06	Food processing	S23	Ferrous metal smelting and pressing
S07	Food manufacturing	S24	Non-ferrous metal pressing
S08	Beverages manufacturing	S25	Metal products manufacturing
S09	Tobacco manufacturing	S26	General purpose manufacturing
S10	Textile clothes	S27	Special purpose manufacturing
S11	Leather manufacturing	S28	Transport equipment manufacturing
S12	Timber and wood processing	S29	Electrical machinery and equipment
S13	Furniture manufacturing	S30	Communication equipment manufacturing
S14	Paper industry	S31	Measuring instruments manufacturing
S15	Printing and industry	S32	Electricity production
S16	Culture and sport activities	S33	Gas production
S17	Oil processing, coking	S34	Water production

Table 2 Summary statistical description

Variable	Unit	Obs.	Mean	Std. dev.	Mix	Max
Y	10^4RMB	612	7570.2	12770.5	32.1	115576.0
K	10^4RMB	612	2459.5	3820.1	79.1	35449.9
L	10^4Persons	612	220.9	207.8	14.5	1110.7
E	10^4TCE	612	4189.9	9240.9	57.2	62908.9
IA	–	612	0.586	0.106	0.362	0.826
ECS	–	612	0.320	0.198	0.039	0.953
OS	–	578	0.316	0.291	0.002	0.998

3 Empirical Analysis

3.1 Results of Fixed-Effects SFA Estimation

As it is shown in Table 3, most variables are statistically significant at the 1–10% levels. Moreover, the estimated value of the standard deviation of inefficiency (σ_u) is significant at the 1% level, indicating that the energy utilization in Chinese industrial sector is indeed inefficient to some extent. In addition, the standard deviation of

Table 3 Results of fixed-effects SFA estimation

	Coefficient	Standard errors
lnk	−2.357***	0.303
lnl	0.536*	0.288
lny	0.713***	0.227
[lnk]2	0.140***	0.043
[lnl]2	0.235**	0.058
[lny]2	0.062***	0.024
lnklnl	0.002	0.064
lnklny	0.044	0.04
lnllny	−0.435***	0.071
t	−0.013	0.041
t2	0.005***	0.001
tlnk	−0.032***	0.007
tlnl	0.042***	0.009
tlny	−0.005	0.007
σu	−2.570***	0.08
σv	−6.732***	0.66
log-likelihood	305.557	

*, ** and *** denote coefficient significant at 10%, 5% and 1%, respectively

stochastic noises (σ_v) is are also significant at the 1% level, implying that the influence of stochastic noises should not be ignored. In this regard, the application of SFA approach is more appropriate and accurate than the conventional DEA approaches

3.2 Energy Efficiency Performance

We calculate the TFEE scores of Chinese 34 sub-industries for the period of 1998–2015 based on the estimation results in Table 3.

Figure 1 shows the average annual TFEE scores between 1998 to 2015. We can see that the average TFEE increases from 1998 until it reaches a peak point in 2001. From then on, the annual TFEE suffers a decline for about 5 years. In 2006–2010, the average TFEE rebounds to grow. However, it experiences a general decline for the period of 2010–2015.

Figure 2 illustrates the average TFEE scores of each sub-industry. We can see that the efficiency scores are on average higher than that in Shen and Lin [17], which may be partly due to the isolation of the individual heterogeneity from the inefficiency term through our fixed effects specification.

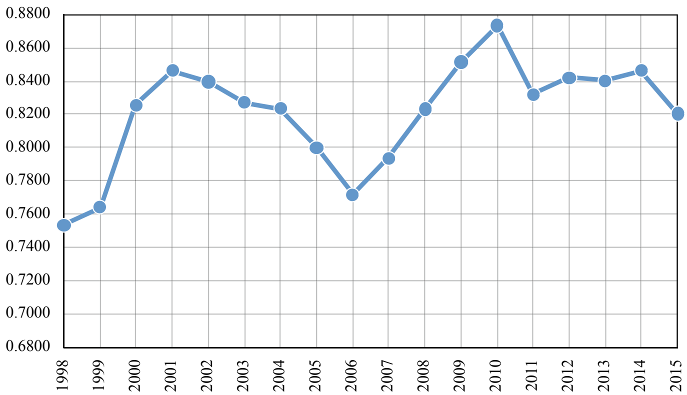

Fig. 1 Average annual TFEE scores

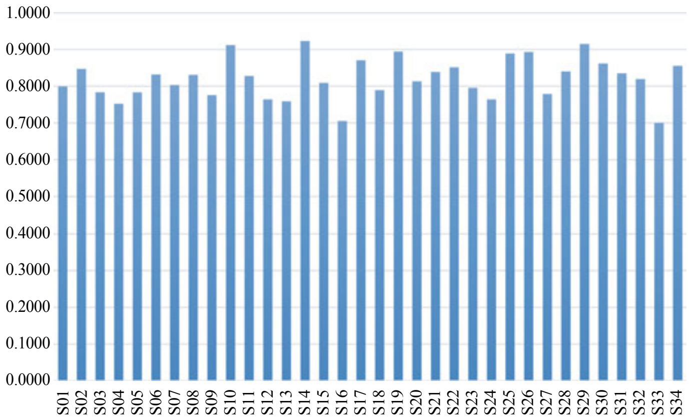

Fig. 2 Average TFEE scores of each sub-industry

Table 4 reports the TFEE scores in every three years. As for individual industries, Paper industry (S14), Electrical machinery and equipment (S29), Textile clothes (S10) perform most efficiently among 34 sub-industries. On the Contrary, Gas production (S33) and Culture and sport activities (S16) have the worst efficiency performance.

3.3 Determinant Analysis and Discussion

The results of the determinant analysis on TFEE are presented in Table 5. The F test in two regression models confirm the overall significance of each regression specification (Table 5).

Table 4 TFEE of Chinese industries

Code	1998–2000	2001–2003	2004–2006	2007–2009	2010–2012	2013–2015
S01	0.588	0.716	0.936	0.897	0.784	0.875
S02	0.687	0.767	0.959	0.954	0.917	0.796
S03	0.963	0.868	0.599	0.699	0.739	0.833
S04	0.943	0.841	0.559	0.719	0.743	0.708
S05	0.958	0.936	0.687	0.641	0.697	0.779
S06	0.779	0.900	0.709	0.707	0.966	0.932
S07	0.672	0.813	0.695	0.742	0.912	0.985
S08	0.861	0.981	0.608	0.648	0.957	0.931
S09	0.650	0.626	0.791	0.912	0.825	0.850
S10	0.875	0.973	0.835	0.939	0.940	0.910
S11	0.930	0.971	0.728	0.694	0.824	0.819
S12	0.920	0.932	0.622	0.647	0.699	0.764
S13	0.565	0.594	0.892	0.789	0.865	0.849
S14	0.900	0.967	0.848	0.884	0.955	0.984
S15	0.829	0.796	0.899	0.837	0.772	0.723
S16	0.655	0.688	0.607	0.590	0.717	0.975
S17	0.957	0.979	0.873	0.839	0.829	0.746
S18	0.881	0.940	0.743	0.793	0.749	0.629
S19	0.779	0.906	0.866	0.898	0.946	0.970
S20	0.665	0.684	0.867	0.954	0.908	0.802
S21	0.844	0.973	0.807	0.825	0.826	0.758
S22	0.826	0.942	0.728	0.863	0.859	0.891
S23	0.966	0.979	0.872	0.721	0.651	0.586
S24	0.929	0.915	0.782	0.712	0.672	0.575
S25	0.970	0.946	0.877	0.866	0.868	0.806
S26	0.758	0.953	0.885	0.903	0.889	0.971
S27	0.551	0.658	0.728	0.846	0.911	0.979
S28	0.613	0.761	0.888	0.970	0.931	0.874
S29	0.807	0.933	0.851	0.945	0.987	0.963
S30	0.653	0.734	0.945	0.960	0.978	0.898
S31	0.704	0.699	0.935	0.936	0.889	0.843
S32	0.629	0.692	0.994	0.950	0.851	0.798
S33	0.512	0.496	0.584	0.729	0.974	0.903
S34	0.739	0.922	0.950	0.965	0.842	0.712

Table 5 The determinant analysis

	Model (1)		Model (2)	
	Coefficient	Standard errors	Coefficient	Standard errors
IA	−3.228***	0.653	−2.254***	0.632
IA^2	2.483***	0.555	2.108***	0.533
ECS			−0.607***	0.065
OS			0.198***	0.054
Constant	1.805***	0.189	1.567***	0.181
F test	14.19***	0.000	29.31***	0.000

*** denote coefficient significant at 1%

In related studies, there are two different mechanism between agglomeration and energy efficiency. One claims that agglomeration promotes energy efficiency, while the other demonstrates that agglomeration has negative effect on energy efficiency. Model (1) provides fixed-effects estimation results of industrial agglomeration. As it is shown, the linear term is significantly negative and the quadratic term is significantly positive. Model (2) also provides the similar evidence. The results seem to support the negative mechanism. Besides, the ECS, measured by coal share, has a significantly negative effect on energy efficiency e at the 1% level, implying the transition from coal to clear energy helps to enhance energy efficiency effectively. The coefficient of OS is significantly positive at the 1% level, indicating that SOEs are inefficient at energy consumption and hinder the increase of energy efficiency. In other words, the sustained SOEs reform benefits the improvement of energy efficiency.

We focus on Model (2) and test the marginal effect of industrial agglomeration on TFEE through taking derivative. Since IA ranges from 0 to 1, the marginal effect of IA is always negative, but this effect will be abated as the increase of IA value. The result means that the present industrial agglomeration hinders the energy efficiency growth. However, negative effect becomes smaller in recent years.

The above results provide an understanding of the determinants on energy efficiency. First, Chinese industrial agglomeration is not helpful to the improvement of energy efficiency, which may be due to that the existing industrial parks pay more attention to economic growth but few attentions to energy use and environmental issues. However, Chinese government has imposed the obligatory reduction goals of energy consumption since the 11th Five-Year Plan (FYP), that is, energy conversation and emission reduction (ECER) program. That may explain the decline of the marginal effect of IA on energy efficiency. Second, to improve energy efficiency, SOEs that are proved to be less productive to private enterprises need to be reformed constantly and deeply. Third, the transition from coal to clear energy are quite beneficial to energy efficiency improvement and need to be pushed on.

4 Conclusion

This paper uses fixed-effects SFA model to measure the total-factor energy efficiency of Chinese 34 industries during the period of 1998–2015. We then investigate the influence of industrial agglomeration on energy efficiency. The empirical results show that industrial agglomeration has a U effect on energy efficiency and the marginal effect of industrial agglomeration on energy efficiency is below zero, implying that the net effect of industrial agglomeration is negative in China's industrial sector over the period of 1998–2015. However, the negative effect becomes smaller since the government has paid more attention to energy conversation and environmental issues. The energy consumption structure, measured by cola share, is negatively correlated with energy efficiency, implying the transition from coal to clear energy is beneficial to the improvement of energy efficiency. The ownership structure is proved to be negatively affecting the energy efficiency, revealing that SOEs are inefficient at energy consumption and impede the improvement of energy efficiency. These results suggest that the government should guide the industrial parks to reduce energy consumption, change the present energy consumption structure to be clearer and deepen the reform of SOEs in the future.

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The Ownership Structure and Corporate Performance of Chinese Technology Hardware and Equipment Listed Companies

Dangshuai Zhang and Wenxing Li

Abstract Technology hardware and equipment industry is one of the most important industries in China, which plays an important role for the development of science and economics. The ownership structure and corporate governance of enterprises in this industry can be used for reference for the reform of mixed ownership of listed companies in China. This paper chooses the mixed ownership enterprises of technology hardware and equipment industry of A-share listed companies from 2011 to 2018 as the research object. Combined with the nature of ownership, this paper empirically examines the influence of ownership structure on the performance of mixed ownership companies in this field from the degree of ownership concentration and ownership balance, and on this basis, we discuss the corresponding governance mechanism of mixed ownership companies.

Keywords Technical hardware and equipment industry · Equity structure · Mixed ownership · Enterprise performance

1 Introduction

In recent years, the reform of mixed ownership has become one of the hot topics in the society. The reform of mixed ownership is of great significance for implementing the socialist economic thought with Chinese characteristics and enhancing the vitality of the state-owned economy. It is worth considering how to implement mixed reform scientifically and effectively, stimulate the vitality of state-owned enterprise, improve their innovation ability and competitiveness, and prevent the loss of state-owned capital at the same time. The purpose of mixed ownership reform is to establish a modern corporate governance system. The separation of management right and

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ownership has always been the key to the governance of modern listed companies. As an important part of corporate governance, ownership structure directly affects corporate performance. In this paper, listed companies in a-share technology hardware and equipment industry from 2014 to 2018 are selected as research samples to empirically test the influence of ownership structure on corporate performance from three aspects: equity concentration, ownership balance and ownership attribute. The results show that ownership concentration of mixed ownership listed companies in this industry is positively correlated with corporate performance. The degree of equity balance in this industry is negatively correlated with corporate performance. The first largest shareholder of state-owned shares is conducive to the improvement of corporate performance. If the first two major shareholders of a company are state-owned shares, it is not conducive to the improvement of enterprise performance.

2 Theoretical Basis and Literature Review

2.1 Theoretical Basis

Property Rights Theory. The main function of property rights is to help a person form his expectations when dealing with others. The basic contents include the rights of use and transfer of resources by action groups, and the right to enjoy income. The property right does not refer to the general material entity from the perspective of economics, but refers to the mutual recognition behavior relationship caused by people's use of the thing. It is used to define the rules of how people gain, lose and compensate each other in economic activities. Property right can produce incentive and restraint in commodity exchange and market economy. It plays an important guiding role for economic reform to maintain the stability of the internal relations such as enterprise organization structure, financial structure and so on.

Incomplete contract theory. Rights that cannot be specified or verified in advance are called residual control rights. The party with the property rights naturally has residual control. He has greater bargaining power and more investment returns when he has the rights not mentioned in the contract, thus has more strong specificity investment incentives in advance. Conversely, the party that loses equity and residual control reduces incentives to invest.

2.2 Literature Review

At present, most scholars divide the mixed ownership economy into macro and micro categories. Rong argued that at the macro level, the mixed ownership economy is dominated by public ownership and the multiple ownership economy develops together [1]. Some scholars pointed out that the current reform of mixed ownership in China mainly refers to the allocation of property rights at the micro level, that is, mixed ownership enterprises composed of state-owned shares and other non-state-owned shares. Zhu proposed that establishing a modern corporate governance system is conducive to solving the incentive problem of managers and agents of state-owned assets, so as to achieve the goal of state-owned enterprise reform [2]. Some scholars found through empirical research that non-state-owned shareholders can effectively restrain the excessive compensation and excessive on-the-job consumption of senior executives of state-owned enterprises and other principal-agent problems, and improve the sensitivity of executive compensation of state-owned enterprises to performance. From the perspective of technological innovation ability, Wu found that mixed ownership enterprises have the strongest technological innovation ability, while state-owned enterprises have the worst [3]. Zhang proposed to solve the principal-agent problem by allocating residual claims and control rights [4].

Scholars have conducted long-term studies on the relationship between ownership structure and corporate performance, but have not reached a consistent conclusion. As for the relationship between equity balance and corporate performance, scholars focus on whether the balance between major shareholders can improve corporate governance and corporate performance [5]. Some studies show that excessive ownership concentration has a negative impact on business performance [6]. However, some scholars draw opposite conclusions, proving that there is a significant positive correlation between the degree of ownership balance and corporate performance. The relationship between the nature of the first largest shareholder and corporate performance is also the focus of scholars. Some scholars believe that corporate performance can be improved when the largest shareholder is state-owned, because state-owned enterprises can provide better development opportunities by their own resources and reputation [7]. However, some scholars believe that the corporate governance efficiency of enterprises with the largest state-owned shareholder is lower than that of enterprises with the largest non-state-owned shareholder. In addition, some scholars have studied from the perspective of the nature of shareholders, trying to study the relationship between heterogeneous shareholders and corporate performance. It is a common phenomenon that the major shareholders of listed companies in China are closely related. Therefore, there may be conspiracy rather than supervision between the major shareholders. When the two major shareholders are state-owned, it is easier for them to reach collusion.

At present, scholars have carried out researches on gem, tourism, state-owned enterprises, trust companies and other fields, but there are few researches on technical hardware and equipment. In view of this, this paper further empirically tested the relationship between ownership structure and corporate performance of mixed-ownership companies in the field of technology hardware and equipment, so as to enrich existing literature studies.

2.3 Innovation

Scholars have conducted long-term research on the relationship between ownership structure and corporate performance, and most existing researches focus on the following issues. The first is the relationship between ownership concentration and corporate performance, and the second is the relationship between ownership balance and corporate performance. The research on the relationship between ownership concentration and corporate performance is quite in-depth. There are few researches on the degree of equity balance and corporate performance. Most of the discussion is based on the linear relationship between them, and there is less discussion on the nonlinear relationship between them. Meanwhile, existing researches pay more attention to the influence of the largest shareholder on corporate performance, while a few researches focus on the checks and balances of the second largest shareholder on the largest shareholder. The impact of the former two major shareholders on state-owned shares on corporate performance was generally ignored.

Therefore, the article first studies the impact of equity concentration and equity balance on company performance, and establishes partial linear panel data. And the corresponding test method is given to select the linear and nonlinear influence mode of equity balance degree on corporate performance. On this basis, we also explore the impact of the first two shareholders are state-owned on corporate performance.

3 Research Hypothesis

Equity structure refers to the proportion of different shareholders or investors in the shares of an enterprise, which is the basis of corporate governance. Mixed ownership listed companies need different kinds of capital to enter, forming a mechanism of mutual checks and balances between shareholders. The decentralized ownership structure facilitates the integration and checks and balances between different capitals. The unreasonable design of ownership structure may lead to the battle of shareholders for ownership and control [8]. From a micro perspective, the foundation and basis of corporate governance is the capital structure (including the equity structure), and the core and focus is the board structure.

3.1 Ownership Concentration and Corporate Performance

Based on the principal-agent theory and information asymmetry theory, when the ownership is too concentrated, the major shareholders will have the actual control right of the company, and the highly concentrated control right will lead to the tunneling phenomenon of the major shareholders, which will damage the interests of the company and the small and medium-sized shareholders, and thus damage the company's business performance [9]. On the other hand, when the equity is too dispersed, the supervision cost of minority shareholders is relatively high, and the free-riding behavior of minority shareholders is easy to happen. The technology hardware and equipment industry belongs to China's science and technology innovation industry, and the equity concentration of emerging industries is relatively low. Therefore, it is reasonable to think that the equity concentration of this industry is positively related to the company's performance. Based on this, hypothesis 1 is proposed:

> H1: There is a positive correlation between ownership concentration and company performance of mixed ownership companies in technology hardware and equipment industry

3.2 Degree of Equity Balance and Corporate Performance

The degree of balance of ownership is mainly reflected in the degree of balance of other major shareholders except the largest shareholder to the largest shareholder. Due to the information asymmetry between controlling shareholders and small and medium-sized shareholders, large shareholders are likely to use controlling shares to damage the interests of small and medium-sized shareholders. Equilibrium of controlling shareholders can form a mechanism of mutual restriction and balance of ownership, weaken the damage of controlling shareholders to the interests of the company, and improve the performance of the company. However, when the balance of ownership is too high, the governance effect of controlling shareholders will be weakened. It is difficult to form an efficient centralized decision-making mechanism, which leads to problems such as insufficient investment and inefficient investment [10]. Based on this, hypothesis 2 of this paper is proposed:

> H2: The influence of equity checks and balances on corporate performance is non-linear, and corporate performance shows an "inverted u-shaped" curve relation with the degree of equity checks and balances.

3.3 Controlling Shareholder Attribute and Corporate Performance

The state-owned shareholders of mixed ownership listed companies usually need to respond to the administrative signals sent by the government and the price signals sent by the market, that is, to take into account the social objectives and economic objectives when making decision.

Generally speaking, state-owned shareholders pay more attention to the social goal of increasing social output. The profit-seeking nature of non-state-owned shareholders inhibits enterprises from bearing policy burdens and attaches more importance to economic objectives, which is to improve corporate profits. Equity heterogeneity reflects the relationship between shareholders with different ownership characteristics. Under the multiple ownership structure, except for the largest shareholder, the second largest shareholder also has great influence on the company [11]. Compared with homogeneous shareholders, heterogeneous shareholders have stronger motivation of supervision and restraint, and homogeneous shareholders are more likely to collude with each other and harm the interests of the company. Based on this, hypothesis 3 is proposed:

H3: When the largest shareholder of the company is state-owned shares, corporate performance can be improved. However, when the two major shareholders are state-owned shares, it is not conducive to the improvement of corporate performance.

4 Sample Selection and Data Sources

4.1 Sample Screening

This paper chooses A-share listed companies in technology and hardware equipment industry from 2011 to 2018 as the research sample. The principles of sample data selection are as follows. ST* companies are eliminated, companies with lost or undisclosed data are eliminated, companies with obvious unreasonable data are excluded, and companies with negative net assets are excluded. The acquired listed companies are divided into two categories: state-owned shares (the largest shareholder is state-owned) and non-state-owned shares (the largest shareholder is non-state-owned). Data of 154 listed companies were obtained. We obtained a total of 6160 sample observations. All the data required in this paper are from the wind database, and we use eviews9.0 software to conduct regression on the samples.

4.2 Variable Design

The explained variable is enterprise performance. For listed companies, enterprise performance is reflected in two aspects. One is the performance of securities market. The second is the product market performance, which is the profitability and operating level of the physical assets of the enterprise, which can be measured by various financial indicators. In the empirical study, we use the return on net assets to evaluate the performance of listed companies comprehensively.

Explanatory variable includes equity concentration, degree of equity balance and the nature of big shareholders. Equity concentration is measured by the proportion of the largest shareholder (TOP1). In order to facilitate our research and make the data approximately normal distribution, we take the logarithm of the shareholding ratio of the largest shareholder. The degree of equity checks and balances is expressed by the ratio of the proportion of shares held by the second to the tenth largest shareholder to that of the first largest shareholder (ZH). The equity attribute is represented by the dummy variable (STATE1) of the nature of the largest shareholder (1 means the largest shareholder is state-owned holding, 0 means non-state-owned holding) and the dummy variable (STATE2) of the nature of the second largest shareholder (the same as STATE1). Equity homogeneity is indicated by STATE1 * STATE2 (1 means that the first two major shareholders are state-owned shares and 0 means that the first two major shareholders are not all state-owned shares).

Control variable includes company size and financial leverage. Company size is expressed in natural logarithm of total assets. Financial leverage (LEV) is expressed in asset-liability ratio. The description of each variable is shown in Table 1:

4.3 Descriptive Statistics

Table 2 is the descriptive statistics of the main variables. The equity concentration of listed companies with mixed ownership in technology and hardware industry is relatively balanced. After the maximum and minimum values are removed, the average value of the shareholding ratio of the largest shareholder is 32.232%. In terms of equity checks and balances, the average value is 0.915, indicating that the equity balance of the industry is moderate.

4.4 Model Construction

Panel data is a kind of two-dimensional data composed of cross-section data and time series. Among panel data, linear panel data is the most commonly used form. However, in the hypothesis of this paper, the influence of some explanatory variables on dependent variables is linear, the effect of some explanatory variables is nonlinear. Therefore, in order to study the influence of ownership concentration degree and ownership balance degree on enterprise performance, this paper plans to establish three inter-nested partial linear panel data models:

$$\begin{aligned} ROE_{it} = \beta_0 + \beta_1 \log(TOP1)_{it} + \beta_2 ZH_{it} + \beta_3 State1_{it} \\ + \beta_4 (State1 * State2)_{(it)} + \beta_5 Size_{it} \\ + \beta_6 LEV_{it} + \varepsilon_{it} \end{aligned} \tag{1}$$

Table 1 Definition of major variables

Variable type	Variable symbol	Variable definition	Variable specification
Dependent variable	ROE	Return on equity capital	Measuring business performance
Independent variable	TOP1	Proportion of the largest shareholder	The natural logarithm of the shareholding ratio of the largest shareholder in a company
	ZH	Degree of equity balance	The sum of the shareholding ratio of the second to the tenth largest shareholder and the ratio of the first largest shareholder
	STATE1	Nature of the largest shareholder	1 represents state-owned holding, 0 non-state-owned holding
	STATE2	Nature of the second largest shareholder	1 represents state-owned holding, 0 non-state-owned holding
	STATE1 * STATE2	Shareholder homogeneity	1 represents the first two major shareholders are state-owned shares, 0 represents not all of the first two shareholders are state-owned
Control variable	SIZE	The company size	The natural log of total assets at the end of the year
	LEV	Financial leverage	Asset-liability ratio

Table 2 Descriptive statistics of variables

Variables	N	Min	Max	Mean	Std
TOP1	1192	8.930	62.960	32.232	3.511
ZH	1192	0.081	4.652	0.915	0.742
ROE	1192	−143.658	79.576	6.315	4.984
LEV	1192	2.740	103.726	37.576	1.675
SIZE	1192	18.836	26.440	21.862	1.187

$$
\begin{aligned}
ROE_{it} =& \beta_0 + \beta_1 \log(TOP1)_{it} + \beta_2 ZH_{it} + \beta_3 ZH^2{}_{it} \\
& + \beta_4 State1_{it} + \beta_5 (State1 * State2)_{(it)} \\
& + \beta_6 Size_{it} + \beta_7 LEV_{it} + \varepsilon_{it}
\end{aligned} \tag{2}
$$

$$\begin{aligned} ROE_{it} = \beta_0 + \beta_1 log(TOP1)_{it} + \beta_2 ZH_{it} + \beta_3 {ZH^2}_{it} \\ + \beta_4 {ZH^3}_{it} + \beta_5 State1_{it} + \beta_6 (State1 * State2)_{(it)} \\ + \beta_7 Size_{it} + \beta_8 LEV_{it} + \varepsilon_{it} \end{aligned} \tag{3}$$

If (3) is true, then neither (2) nor (1) can be established. If (2) is true, then (1) cannot be established. We need to choose the most appropriate model from them as the final empirical model. Therefore, it is necessary to judge whether there are significant differences among the three models. That is, the original hypothesis is put forward.

H0a: the quadratic model is not significantly improved than the linear model.
H0b: The cubic model is no better than the quadratic model. On the basis of these two null hypotheses, the following test statistics can be constructed:

$$\begin{aligned} F^{(linear V.S. quadratic)} = \frac{RSS^{(linear)} - RSS^{(quadratic)} / (df^{(linear)} - df^{(quadratic)}}{\frac{RSS^{(quadratic)}}{df^{(quadratic)}}} \\ \sim F\left(df^{(linear)} - df^{(quadratic)}, df^{(quadratic)}\right) \end{aligned} \tag{4}$$

$$\begin{aligned} F^{(quadratic V.S.\ cubic)} = \frac{RSS^{(quadratic)} - RSS^{(cubic)} / (df^{(quadratic)} - df^{(cubic)}}{\frac{RSS^{(cubic)}}{df^{(cubic)}}} \\ \sim F\left(df^{(quadratic)} - df^{(cubic)}, df^{(cubic)}\right) \end{aligned} \tag{5}$$

In the (4) and (5), $RSS^{(linear)}$, $RSS^{(quadratic)}$, $RSS^{(cubic)}$ are the sum of squared residuals of (1), (2), (3). $df^{(linear)}$, $df^{(quadratic)}$, $df^{(cubic)}$ are corresponding degrees of freedom. Since the larger the statistical value of F is, the more unfavorable it is to the null hypothesis, the hypothesis test here is one-sided.

The actual model selection process can be divided into two steps. The first step is to use $F^{(linear V.S. quadratic)}$ to check if H0a can be established. If accepted, a linear model is established, and if rejected, at least a quadratic model need to be established. Second, use $F^{(quadratic V.S. cubic)}$ to check if H0b is true. If accepted, a quadratic model is established, and if rejected, a cubic model need to be established.

4.5 Empirical Regression Analysis of Ownership Structure and Corporate Performance

After Hausman test, the panel data fixed effect model is used for empirical regression. Second, the model is builded according to the types with and without control variables. In each type, linear model, quadratic model and cubic model are considered respectively. The estimated results without control variables are shown in Table 3, and the estimated results with control variables are shown in Table 4. Through the F

Table 3 Parameter estimation results

Variables	Linear model	Quadratic model	Cubic model
C	8.320***(7.101)	10.709***(6.512)	12.047***(5.366)
ZH	2.855**(−2.356)	7.685***(−2.919)	12.099**(−2.127)
ZH^2		1.439**(2.066)	4.410(1.273)
ZH^3			−0.485(−0.875)
R-squared	0.310	0.314	0.314

Note: ***, **, * indicate significant at the 1, 5, and 10% levels

Table 4 Parameter estimation results

Variables	Linear model	Quadratic model	Cubic model
C	−53.891**(−2.273)	−52.949**(−2.237)	−51.962**(−2.187)
LOG(TOP1)	6.345**(2.338)	5.688**(2.084)	5.664**(2.074)
ZH	3.031**(−2.394)	7.838***(−2.885)	10.403*(−1.835)
ZH^2		1.392**(1.999)	−3.119(0.912)
ZH^3			0.282(−0.516)
STATE1	3.018*(1.934)	2.517(1.597)	2.518(1.597)
STATE1*STATE2	−5.894***(−2.982)	−5.659***(−2.864)	−5.629***(−2.847)
LEV	−0.263***(−4.987)	−0.268***(−5.073)	−0.266***(−5.029)
SIZE	2.329**(2.535)	2.506***(2.719)	2.497***(2.708)
R-squared	0.335	0.338	0.338

Note: ***, **, * indicate significant at the 1, 5, and 10% levels

Table 5 Odel form selection test result

Model comparison	F-statistic	First degree of freedom	Second degree of freedom	p	Conclusion
Without control variables					
Linear V.S. quadratic	4.269	1	891	0.039	Establish a cubic model
Quadratic V.S. cubic	0.766	1	890	0.382	Establish the quadratic model
Containing control variables					
Linear V.S. quadratic	4.317	1	888	0.038	Establish a cubic model
Quadratic V.S. cubic	0.327	1	887	0.567	Establish the quadratic model

test for model form selection given above, the test results are shown in Table 5. For the degree of equity checks and balances, the quadratic model should be established eventually. This result significantly supports that the influence mode of ownership balance degree on corporate performance is quadratic parabola nonlinear. In addition, it can be seen from Table 4 that the ownership concentration ratio of mixed ownership listed companies in the technology hardware and equipment industry is positively correlated with corporate performance, which means that the ownership concentration within a certain range is conducive to improving corporate performance. At the same time, we can see from Table 4 that the nature of ownership, which is the largest shareholder, has no significant impact on corporate performance. Many literatures believe that ownership nature can significantly affect corporate profitability, especially state-owned enterprises, which tend to have more profitability because they tend to monopolize resources and enjoy preferential policies. The empirical results of this paper suggest that ownership nature is not a significant influence factor for the company's value creation ability, which provides a theoretical basis for private enterprises to improve company value.

5 Conclusions and Recommendations

In this paper, listed companies in a-share technology hardware and equipment industry from 2011 to 2018 are selected as research samples to empirically test the influence of equity structure on corporate performance from three aspects: equity concentration, equity checks and balances and ownership attribute. The results show that equity concentration of mixed ownership listed companies in this industry is positively correlated with corporate performance. This indicates that the ownership concentration ratio of this industry is relatively low compared with other industries. There is a quadratic parabolic nonlinear relationship between the degree of equity balance and corporate performance of listed companies in the technology hardware and equipment industry.

This paper also examines the relationship between the nature of the first two major shareholders and corporate performance. The empirical results show that there is no significant correlation between the first largest shareholder and corporate performance. This suggests that when the largest shareholder is state-owned, it may not be easier to access resources. At the same time, it also provides a theoretical basis for private enterprises to stimulate their vitality and improve the efficiency of capital use. The research also found that when the top two shareholders of listed enterprises in the technology hardware and equipment industry are state-owned shares, it is negatively correlated with corporate performance. This indicates that the checks and balances between the first two major shareholders are not obvious, and there is a greater possibility of collusion between the two major shareholders. An important enlightenment for us is that the checks and balances of heterogeneous shareholders are better than those of homogeneous shareholders.

In view of this, this paper argues that listed companies with mixed ownership in the technology hardware and equipment industry should pay attention to the governance effect of the equity structure and strengthen the corporate governance mechanism. The mutual encouragement and supervision between major shareholders is helpful to the development of the enterprise, which can avoid the situation of "dominance" and "insider control". From the perspective of the degree of equity checks and balances, excessively high equity checks and balances may reduce the decision-making efficiency. But the company's equity structure should not be too decentralized. Excessive decentralization of ownership structure is likely to lead to free-riding behavior of minority shareholders, so the degree of equity checks and balances should be kept at an appropriate proportion. In addition, institutional investors can be actively introduced. Institutional investors can not only inject social capital into listed companies in the technical hardware and equipment industry, but also guide the diversified development of the company's equity structure.

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The Multiple Dimensions of Food Security of China in the Context of Labor Costs Rising

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Abstract Labor is an important input factor in food production process. Labor costs of food production process of China have shown a rapid increasing trend since 1995. This paper selects the period of 1995–2017 as the research sample period and adopts the threshold linear conversion method to explore the status and changing trends of China's food security from four dimensions, food availability, food access, food utilization and food stability, in the context of labor costs rising. The research results show that among the four dimensions China has the best security status in food availability dimension, and that China has been in a secure state in food availability dimension since 2008. The security status of food stability dimension continued to fluctuate during the whole sample period and has gradually improved since 2008. Both food access dimension and food utilization dimension were in an insecure state in the sample period.

Keywords Food security · Multiple dimensions · Food production variability

1 Introduction

Food security is an important security issue related to the national economy and the people's livelihood. In the past forty years, especially since the implementation of the household contract responsibility system, China has made remarkable achievements

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in the fields of food production, agricultural science and technology, and agricultural economic growth. From 2004 to 2015, China's total food production increased by 40.71%. In 2016, China's food output showed a slight decline. Then in 2017, China's total food production reached the peak of 661.61 million tons. The average annual growth rate of food production of China is also in the leading position in the world.

On the other hand, the Chinese government has always attached great importance to the issue of agriculture, rural areas and farmers. The central and local governments have introduced various policies and measures to promote rural development and agricultural progress, and to increase farmers' income, which also bring about sweet troubles, namely the rising of labor prices in food production. The labor costs of food production process of China are constantly increasing. In the past three decades, China's agricultural labor prices have grown rapidly, while agricultural machinery prices have remained relatively stable. In China's food production process, labor costs take a relatively high proportion of the total costs. However, in agricultural-developed countries such as the United States and Canada, mechanical costs are always occupied the largest share in the total costs. In addition, with the acceleration of urbanization and industrialization, massive young and middle-aged rural labors migrate to urban areas or take jobs outside the agricultural sector. Rural surplus labors have decreased, and the rural population has become aging and feminine, which will further reduce the supply of rural labors. Thus, the labor costs of food production will be further raised in the future. This paper measures the labor costs of food production by per acre labor costs of food production. Figure 1 shows that the labor costs of food production have grew rapidly since 1995. The labor shortage phenomenon occurred in 2004, and then the labor costs increased at a higher speed [1]. The increase in labor costs will affect farmers' choice of factors input and planting varieties, which will influence food security. Therefore, this paper will explore the changes in China's food security in the context of labor costs rising.

In the study of food security, scholars have established rich indicators to measure food security. The Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD) and World Food Programme (WFP) together construct the prevalence of undernourishment indicator

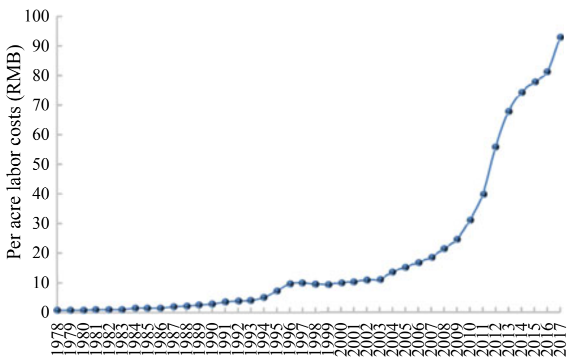

Fig. 1 Per acre labor costs of food production: 1978–2017

(POU) to measure the food security of individuals or households, and this indicator is calculated and reported based on a large number of micro-questionnaires [2]. Indicators such as food consumption score (FCS) and household dietary diversity score (HDDS) are also widely used to measure food security at the household level [3]. Otherwise, Leroy et al. find that each of these indicators is only a measure of one dimension of food security, namely food access [4]. Vaitla et al. use exploratory factor analysis (EFA) to study indicators measuring food security commonly used in existing studies. They find that the correlation between these indicators show that they all reflect the connotation of food security. But there are also significant differences among these indicators, which means each of them also contains special information that cannot be fully replaced by other indicators. Therefore, they conclude that there is no a gold standard indicator to measure food security. An ideal approach is to select multiple indicators to comprehensively assess food security [5]. FAO researchers also believe a standalone indicator such as POU, is not able to capture the complexity and multi-dimensionality of food security of a country or a region, thus they propose an evaluation indicator system to comprehensively assess food security from four dimensions, availability, access, stability and utilization [6]. Researchers of the Economist Intelligence Unit (EIU) also choose to build a multi-level indicator system to assess food security. They assess food security from four dimensions, affordability, availability, quality and safety, and natural resources and resilience. And they report Global Food Security Index and national rankings every year [7]. Timmer [8] focus on the implementation of food security in Asian countries. He finds that three macro-level strategies of Asian countries are important to help them achieve food security. Firstly, Asian countries keep economic growth. Secondly, they have a relatively fair income distribution system. Finally, they achieve domestic food consumption price stability by the government intervention. Aurino [9] think that domestic food production, import capacity, adequate food reserves, and a sound food aid system are important aspects of achieving national food security. Zhang et al. [10] analyze national food security from eight aspects, supply, distribution, consumption, utilization efficiency, food reserves, stability, sustainability, and government regulation, and they use Chinese data to make empirical analysis. Yao et al. [11] analyze food security from four dimensions, food production resources, food availability and stability, food access, food utilization.

In a nutshell, the existing research has not reached a consensus conclusion on the measurement dimensions of food security at the macro-level. At the same time, there is no research focusing on food security changes in the context of labor costs rising, while labor costs are the key costs of food production. Therefore, this study will try to answer the following question. How do the multiple dimensions of food security change in the context of labor costs rising?

2 Indicators and Methodology

2.1 Indicators and Data

This study refers to the indicator system established by FAO, IFAD, and WPF in researching food security. It analyzes the status and the changing trends of food security from four dimensions, availability, access, utilization, and stability. The relationship among the four dimensions is shown as Fig. 2.

Food availability reflects whether a country or a region can provide a sufficient amount of food for its residents. This paper selects per capita food output as a measure of food availability. Per capita food output is a positive indicator and data are gathered from the official website of National Bureau of Statistics of China. National Medium-Term and Long-Term Plan for Food Security of China (2008–2020) proposes that per capita food consumption should be more than 395 kg by 2020, so this paper sets the security threshold of per capita food output at 395 kg.

Food access represents the physical or economic way to get food and measures how difficult it is for people to get food. This paper selects Gini coefficient to describe the difficulty of a country's residents in obtaining food from the economic perspective. Gini coefficient describes the income gap of a country's residents. Gini coefficient is a negative indicator and data are collected from the 2018 China Yearbook of Household Survey. The smaller the income gap, the more balanced the income distribution of all residents, and the easier it is for all residents to obtain food. It has been widely accepted that the income gap of a country's residents is relatively reasonable when Gini coefficient is less than 0.4. Therefore, the security threshold value of Gini coefficient is set at 0.4.

Food utilization reflects the use of food by residents, and it is the outcome dimension of the food security assessment system. This paper selects prevalence of undernourishment (POU) to describe food utilization. POU is a negative indicator and data are derived from The State of Food Insecurity in the World published by FAO every year and FAOSTAT database. Refer to the prevalence of undernourishment data values of Europe and North America, we set the security threshold value of POU at 2.5%.

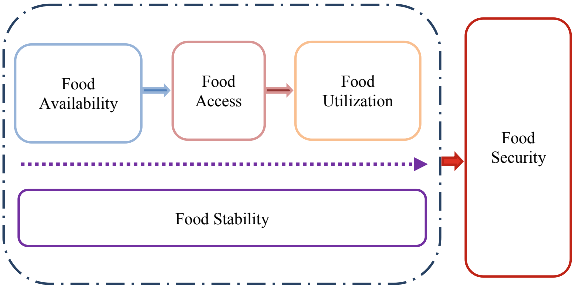

Fig. 2 Conceptual framework of food security

Food stability represents a stable, continuous supply of food. It also presents the ability to resist external shock. Therefore, this paper selects the absolute value of the variation rate of food production to describe the stability and sets the security threshold value at 5% [12]. The measurement method of absolute value of variation rate of food production is put in the next section. It can be seen from Fig. 1 that the labor costs of food production have increased rapidly since 1995. Therefore, the sample period of this study is the period of 1995–2017. This paper will study the security status and changing trends of the four dimensions of China's food security during this period.

2.2 Methodology

The calculation equation of absolute value of variation rate of food production is shown in (1), where y_t is the actual food output in t-year, and $\hat{y}_t$ is the estimated food output in t-year. $\hat{y}_t$ only considers the time trend. This paper establishes linear, quadratic and cubic models (2), (3), and (4) to estimate $\hat{y}_t$. The estimation results of each model are shown in Table 1. The coefficient estimation results of the core variables of (4) are not significant. The coefficient estimation results of (2) and (3) are significant. To determine an appropriate model form from (2) and (3), we perform the Ramsey RESET test on (2) to test if high-order terms should be included. The Ramsey RESET test results strongly reject the null hypothesis that the model should not contain higher order terms, $F(3,63) = 23.08$. Therefore, this paper chooses (3) to estimate the time trend food production $\hat{y}_t$.

Table 1 Estimation results

Coefficient	Model (2)	Model (3)	Model (4)
β_0	3300.533***[a] (3.98)[b]	6736.935*** (6.29)	7629.603*** (4.85)
β_1	776.268*** (37.15)	481.719*** (5.88)	331.913* (1.69)
β_2	–	4.269*** (6.29)	9.657 (1.47)
β_3	–	–	−0.052 (−0.83)
R^2	0.954	0.963	0.964
F-test	1380.411	852.07	565.573
Sum of residuals	7.557E + 08	6.077E + 08	6.012E + 08

[a] $p < 0.1$, *; $p < 0.05$, **; $p < 0.01$, ***
[b]The value in parentheses is the t-value

$$vr_t = \left|\frac{(y_t - \hat{y}_t)}{\hat{y}_t}\right| \tag{1}$$

$$\hat{y}_t = \beta_0 + \beta_1 t \tag{2}$$

$$\hat{y}_t = \beta_0 + \beta_1 t + \beta_2 t^2 \tag{3}$$

$$\hat{y}_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 \tag{4}$$

This paper adopts the threshold linear conversion method to convert original data into food security scores by (5) and (6). The calculation process of positive indicators is shown in (5), and the calculation process of negative indicators is shown in (6). Where S_{ij} is the security score of *j* indicator (dimension) in *i*-year after conversion, x_{ij} is the original data value of *j* indicator in *i*-year, and x_j^* is the security threshold value of *j* indicator. x_{min} is the theoretical minimum of *j* indicator. When there is no the theoretical minimum, x_{min} is set at the minimum of sample data of *j* indicator. x_{max} is the theoretical maximum of *j* indicator. When there is no the theoretical maximum, x_{max} is set at the maximum of sample data of *j* indicator. When S_{ij} is equal to 100, it indicates *j* indicator (dimension) is in a secure state in *i*-year. If S_{ij} is more than 100, it means *j* indicator (dimension) is in a good secure state in *i*-year. If S_{ij} is less than 100, it means *j* indicator (dimension) is in an insecure state in *i*-year. The threshold linear conversion method can directly describe the security status and the changing trends of each dimension. By comparing S_{ij} to the security threshold score 100, the security status can be easily judged.

$$S_{ij} = \frac{x_{ij} - x_{min}}{x_j^* - x_{min}} \times 100 \tag{5}$$

$$S_{ij} = \frac{x_{ij} - x_{max}}{x_j^* - x_{max}} \times 100 \tag{6}$$

3 Results Analysis

3.1 Food Availability

Table 2 shows the per capita food output and food availability security score of China in the period of 1995–2017. From 2008 to 2017, China's food availability security scores were greater than the security threshold of 100, and the security score kept rising. The security score in 2015 reached the peak of 121.96. This shows that in food availability dimension, China's food security status has continued to improve.

Table 2 Food availability security score: 1995–2017

Year	Per capita food output (kg)	Food availability security score	Year	Per capita food output (kg)	Food availability security score
1995	387.28	98.05	2007	382.54	96.85
1996	414.39	104.91	2008	403.38	102.12
1997	401.74	101.71	2009	405.19	102.58
1998	412.50	104.43	2010	417.96	105.81
1999	405.82	102.74	2011	437.82	110.84
2000	366.04	92.67	2012	453.27	114.75
2001	355.89	90.10	2013	464.48	117.59
2002	356.96	90.37	2014	468.86	118.70
2003	334.29	84.63	2015	481.76	121.96
2004	362.22	91.70	2016	479.04	121.28
2005	371.26	93.99	2017	477.21	120.81
2006	379.89	96.17	–	–	–

However, during the period of 2000–2007, the food availability security score was less than the security threshold of 100, and in 2003 it was only 84.63. There are two main reasons for the decline in per capita food output in 2000–2007. One reason is the reduction of the area of cultivated land. In the process of urbanization and industrialization, a large amount of cultivated land is occupied, and considerable agricultural land is changed into industrial land or residential land. The reduction in cultivated land has a directly negative effect on food production. The other reason is that the decline in food prices weakens farmers' enthusiasm for planting grain. In this period, the market price of food was low, while the labor costs and the fertilizers costs sharply increased. Thus, the profit of farmers decreased. To maximize the benefits, a lot of farmers made decisions to reduce food cultivation.

3.2 *Food Access*

Table 3 shows Gini coefficient of the income gap of Chinese residents and food access security score from 1995 to 2017. The food access security score experienced a rapid decline in the period of 1996–2008. The security score has increased slowly since 2009, but it was still in an insecure state. In the sample period, except Gini coefficient in 1996 and 1997, Gini coefficient in the rest years was more than 0.4. Thus, the income gap of Chinese residents was unreasonable in the sample period. The widening income gap indicates that a minority owns the majority of income in income distribution. For the poor, this means that they are at a disadvantage in food economic access, and that it is difficult for them to purchase sufficient, high-quality food to meet basic living requirements. In order to strengthen food access

Table 3 Food access security score: 1995–2017

Year	Gini coefficient	Food access security score	Year	Gini coefficient	Food access security score
1995	0.415	97.50	2007	0.484	86.00
1996	0.398	100.42	2008	0.491	84.83
1997	0.398	100.37	2009	0.49	85.00
1998	0.403	99.45	2010	0.481	86.50
1999	0.416	97.32	2011	0.477	87.17
2000	0.438	93.63	2012	0.474	87.67
2001	0.447	92.12	2013	0.473	87.83
2002	0.450	91.67	2014	0.469	88.50
2003	0.479	86.83	2015	0.462	89.67
2004	0.473	87.83	2016	0.465	89.17
2005	0.485	85.83	2017	0.467	88.83
2006	0.487	85.50	–	–	–

security of the whole country, the Chinese government should focus on the issue of food access for the poor. First of all, people in poverty should be provided direct food aid, especially those who are not living in major food production areas or those who are living in remote rural areas. Besides, the Chinese government is ought to keep working hard to help the poor to increase their income, and strengthen their economic ability to obtain food. In addition, the government should improve the income distribution and redistribution system, narrow the gap between the rich and the poor, and make income distribution more equitable. Equitable income distribution is an effective measure to enhance food access security, which has been proved by practices of many Asian countries [8].

3.3 *Food Utilization*

Table 4 shows the prevalence of undernourishment (POU) of the total population of China and food utilization security score from 1995 to 2017.

In the period of 1995–1999, China's food utilization security score continued to improve, but it was still less than 100. And the prevalence of undernourishment was more than the security threshold of 2.5%. The food utilization dimension represents the final outcome of food production, supply, distribution, and consumption, and this dimension is closely related to citizens' health. Although Table 2 shows that per capita food output of China has exceeded the security threshold in recent years, indicating that China has good food production and supply capacity, Chinese residents' food access and utilization still need to be greatly improved. In 2017, prevalence of undernourishment of China was 8.70%, and it was more than triple times of the

Table 4 Food utilization security score: 1995–2017

Year	POU	Food utilization security score	Year	POU	Food utilization security score
1995	13.00%	89.23	2007	14.10%	88.10
1996	13.00%	89.23	2008	13.40%	88.82
1997	11.00%	91.28	2009	12.60%	89.64
1998	9.00%	93.33	2010	11.80%	90.46
1999	9.00%	93.33	2011	11.10%	91.18
2000	15.90%	86.26	2012	10.40%	91.90
2001	15.80%	86.36	2013	9.70%	92.62
2002	15.70%	86.46	2014	9.10%	93.23
2003	15.70%	86.46	2015	8.80%	93.54
2004	15.50%	86.67	2016	8.70%	93.64
2005	15.20%	86.97	2017	8.70%	93.64
2006	14.80%	87.38	–	–	–

security threshold of 2.5%. To improve this situation, China should accomplish the following two tasks. The first task is that relevant safeguards should be provided for the poor to help them get enough food to meet basic survival and physical health needs. Second, the society need advocate and disseminate a rational diet concept and enhance diet health education. On the basis of ensuring sufficient food for basic living for its people, China should also pay attention to the balanced structure of food supply and ensure the diversity of food.

3.4 Food Stability

The absolute value of variation rate of food production can be estimated by (1) and (3). Table 5 shows the absolute value of variation rate of China's food production from 1995 to 2017 and the food stability security score. It can be found that China's food stability security fluctuated from 1995 to 2017. 2008 was a watershed, and China's food production fluctuated drastically from 1995 to 2008. After 2008, the food stability showed a secure state, indicating that the country can serve all citizens stable and continuous supply of food. The food stability is affected by many factors such as input of production factors and natural disasters. As China has the largest population in the world, it is necessary for China to guarantee stable production of food. In particular, a sharp reduction in food production will seriously affect the food security status of a country with a large population. Therefore, China needs to do the following works. First of all, China should ensure the stability of the food production factors input, especially maintain China's cultivated land area and improve the quality of cultivated land and soil. Second, local governments need to assist food planters in disaster prevention and mitigation. In recent years, natural disasters affected by

Table 5 Food stability security score: 1995–2017

Year	Absolute value of variation rate of food production	Food stability security score	Year	Absolute value of variation rate of food production	Food stability security score
1995	5.31%	99.02	2007	8.02%	90.40
1996	11.61%	79.00	2008	4.50%	101.58
1997	7.91%	90.77	2009	4.86%	100.44
1998	8.74%	88.11	2010	3.07%	106.14
1999	6.15%	96.36	2011	0.51%	114.26
2000	7.20%	93.01	2012	3.40%	105.09
2001	11.02%	80.88	2013	5.07%	99.77
2002	12.76%	75.37	2014	4.79%	100.68
2003	19.69%	53.34	2015	6.74%	94.46
2004	13.03%	74.50	2016	4.51%	101.56
2005	11.38%	79.74	2017	2.32%	108.51
2006	8.08%	90.21	–	–	–

climate change have occurred frequently. Conducting disaster prevention and implementing emergency measures are important measures to maintain food production and protect the interests of farmers.

4 Conclusion

In the context of labor costs rising of food production, this paper uses the threshold linear conversion method to research the status and changing trends of China's food security in the period of 1995–2017 from four dimensions, food availability, food access, food utilization and food stability. The results show that in the context of labor costs rising, thanks to the mechanization of food production and the widespread use of new technologies, China's food availability has been in a secure state in recent years and its security score has continued to increase. Food access was always in an insecure state in the sample period. The deep income gap between the rich and the poor leads to unfair access to food at the economic level, which seriously affects the poor to obtain sufficient food. Food utilization continued to improve in the sample period, but it was still insecure. China has a secure food production capacity. How to ensure all citizens making better use of food is the focus of the next work. The security status of food stability fluctuated in the sample period. Since 2008, it has begun to show a secure state. Ensuring stable supply of food production factors, especially cultivated resources and agricultural labors, and strengthening disaster prevention and mitigation work are important for China to achieve food stability.

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The Potential Effects of New High-Speed Corridor Towards Planning New Towns: Reflection on a Case Study

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Abstract Turkey is one of many countries which have been carrying out some changes in transportation policies seeking functional infrastructure of Urban and Regional high speed rail project to attractive enough to accommodate the planned number of people in new town. This article analyzes the various impacts of new *high-speed* rail investment on new towns. Ankara Sivas high speed rail project has been analyzed. A Cost-Benefit Analysis method is conducted; the study was fulfilled that Ankara-Sivas high-speed Corridor has an efficient value for passengers in willing to live in new towns.

Keywords Urban planning · New towns · Cost-Benefit Analysis · Ankara-Sivas high-speed corridor

1 Introduction

This article sheds light on the link between urban planning and appropriate transport networks. Increasing transport network of passengers is considered the main target of planners to settle new towns. Absent of transport plans and infrastructure of traffic networks is one of the most important factors causing problems for passengers and problems in willingness to live in the new towns. The historical facts on setting new towns and urbanization confirm that citizens willing areas near possible water channels and transportation infrastructure of road and railway to make contacts with

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other communities [1]. In spite of the association between transport infrastructure and the expansion of new towns, the procedures of new town planning and design in many new towns are complicated issue in turkey because the increasing of population and urbanization issue. The urban crisis and social pressures the planners do not include planning of traffic and transport infrastructure [2]. So, this paper Ankara Sivas high speed project has been analyzed. Social benefits and costs analysis of HSR project is studied to defeat the troubles of non-sustainability and non-willing of the new towns. During the last decades, Turkey has achieved substantial economic and industrial development. With a population of 81 million, the country has 63230 km of highways and 15000 km of railways. Highway transportation accounts for 95% of freight and passengers while the railways convey 4% of the demand [3]. Ankara–Sivas HSR project is under construction with 406 km length high-speed railway in Turkey, where journey time savings between two cities will be 91 min, as well as will serve extension of the Ankara-Istanbul HSR. Length of the existing railway between Ankara and Sivas is 603 km and the travel time is 12 h. It is aimed to construct a new high-speed line, which is compatible with 250 km/h speed, double-track, electrified and signaled, with a Project planned to reduce the travel time between the two cities to 2 h and 51 min. By examine whether Ankara-Sivas corridor utilizes its railway performance on new towns. A cost-benefit analysis was performed to show that net present value NPV of this project will be positive or not.

2 Literature Review

The significance of evaluating transport modes concurrently stems from the fact that transport networks are considered as the pillar of sustainable metropolitan improvement. Decision making units in transportation projects have been used many methods to support and evaluate the decision making practice, one of them is A Cost-Benefit Analysis (CBA) [4]. Investing in large scale infrastructure projects such as HSR is vital decision, in these kinds of investments the major consideration is the high capital cost in terms of building the high-speed infrastructure, maneuver and preservation expenses [5]. But practical decision makers are focusing on social benefits more than the financial cost in public sector for assessing the distribution of costs and benefits within society [6]. Flyvbjerg, Skamris clarified that economic evaluations of transportation infrastructure are very dependent on predictions of ridership and changes in travel behavior. These factors are usually based on models which can generate significant forecast errors for a variety of reasons and they found that ex-ante analysis of transport infrastructure usage predictions were often wrong, as using estimations for rail passenger range from 66 to 169% (95% confidence interval), with these forecasts often not becoming more accurate over time [7]. Quinet found that from a theoretical standpoint of CBA methods, all the costs and benefits of the transportation projects are qualified financially but practically CBA processes a consistent value of travel-time savings and increases in safety [8]. Increasingly, gas emission, pollution and noise effects, but beyond these, the inclusion of different kinds of benefits, especially social and environmental benefits is inconsistent. discovered many studies have shown that the same projects evaluated using CBA guidelines from different countries can lead to divergent outcomes that would change the evaluation decision from build to no build and vice versa.

Iacono and Levinson found that CBA is not a convenient tool for large-scale projects because CBA generally focuses on local impacts but large scale projects such as transportation infrastructure also have regional impacts [9]. Laird assumed that the CBA model is liable to underestimate wider economic benefits to account for agglomeration impacts and associated increases in productivity [10]. Donaldson considered the costs associated with a transportation project is more basic to calculate than the benefits, where the infrastructure costs and operations costs come from easily available data [11–13]. A growing issue with VOT evaluations is the question of how productive time is while traveling. Joslin examined in their study on time evaluation of avoiding accidents risks and fatalities, similar to VOT assessment, the value of avoiding injury or death varies from country to country [14]. Currie discussed in addition to the direct effects of new transportation infrastructure, derived impacts associated with transportation projects [15]. These derived benefits are greenhouse gas reduction, environmental air quality, pollution impacts, noise reduction, land use influences, and agglomeration benefits. Pearce and Quinet concluded that evaluation and monetizing derived impacts can be complex to establish, and many procedures have to be for assessments such as for local air pollution [8–16]. A physical relation is established between particulates in the air and adverse health effects. The hedonic price method is used for the evaluation of noise cost by comparing the differences in the price of noise-related goods with different noise levels. For greenhouse gas impacts, a monetary value is assumed GHG impact of each passenger per kilometer travelled for different modes [16]. With conventional methods to CBA, there are concerns that the impacts on different users or non-user group are poorly understood and that some impacts are not well quantified [9]. At the beginning, CBA mainly avoided evaluating environmental and social cost and benefits and paid attention the direct costs (infrastructure-operation) and savings time and money associated with transportation projects [16]. More recently, CBA has been expanded to encompass a wider range of impacts such as environmental impacts and social impacts. Iacono recommend and improved the CBA process by using changes in land value in accessing the benefits of local users on a micro-economic scale rather than calculating times savings multiplied by the value of time quantified [9].

Nash highlighted the relation between the Gross Value Added (GVA) and the Net Present Value (NPV) in estimating the impacts of large transport. His study was on HSR project between two cities, they found the NPV present four times of GVA where GVA is planned at 15 billion GBP per year while the NPV calculated over 60 years is 63.6 billion GBP. The difference is due to many factors but includes GVA's ability to better capture trans formative and land value impacts; they concluded that the GVA is considered as a tool in the evaluation of large transportation project that CBA and GVA are important to have macroeconomic and economics grounds impacts [10]. Macharis identified that deciding on building a transport project is

Table 1 Brief data of Ankara Sivas HSR project

Terminal	Ankara-Sivas HSR
Average commercial speed (s)	250 kms/h
Intermediate station	Yerköy-Sivas, Kırıkkale-Yerköy, Kayaş-Kırıkkale, Ankara-Kayaş
Boarding time (between services)	15 min
Route length	Approximately 406 km
Estimated journey time	2 h and 51 min
Scheduled train frequency and operating hours (daily)	56/24 pairs of trains
Train capacity	Approximately 330 passengers per hour per direction
Estimated completion date	2020
Commencement date	2008
Project timeline	40 years
Construction period	5 years
Operation period	35 years
Passenger flow volume (2020)	About 8250 passengers per day travelling between Ankara to Sivas
Ticket price	27.4 USD $
Project costs	USD $2.26 billion
Carbon emission	15% of that of aircraft/25% of that of on land
Environmental protection	Decreasing of pollution by some 600 tons of NOx and 160,000 tones of CO2 per year
Improving the quality of land/meter square	350000000 m^2
Growth of international collaboration/percent t/year	5%
Increasing of regional productions/ton/year	500000 tons

inevitably a complicated process, requiring the weighing of many different factors both quantitative and qualitative (environment, social impacts, economic) [17].

This study investigates whether Turkey utilizes its Ankara-Sivas HSR project and identifies the impacts of this project on new towns, brief project data is summarized in Table 1.

3 Research Methodology and Data Analysis

Shing Chena focused on the impact factors of the Trans-European Network and finished that the rail corridor affected the economy of the region positively, mainly in the eastern side. Along it seems probable that the Ankara-Sivas high speed corridor will impact turkey positively as well improves the accessibility of the region [18]. For the current CBA method depends on evaluation of the proposed project costs in terms infrastructure, operating and external costs over its useful life as well as the benefits expected to accumulate from the project. These time-streams of benefits and costs need to be converted to a common time base due to the time-value of money. That is a dollar invested today at annual interest rate r is "worth" $(1 + r)$ one year from now. In other words, \$1 at Year 0 is equivalent to $\$(1 + r)$ at time Year 1. Future year benefits and costs can both be "discounted" back to their Year 0 equivalent values called their Net Present Value (NPV) [19, 20]. That is if

B_{it} = Total benefits accruing from project i in year t.
C_{it} = Total capital and operating costs incurred by project i in year t.
N = Project assessment period (years).
R = Annual interest rate used to discount future year benefits and costs.

Then:

NPB_i = Net present value of benefits over the project lifetime

$$\sum\nolimits_{t=0,N} B_{it}/(1+r)^t \tag{1}$$

NPC_i = Net present value of costs over the lifetime of project

$$\sum\nolimits_{t=0,N} C_{it}/(1+r)^t \tag{2}$$

Then the project is considered economically viable if

NPV = Net present value of the project

$$NPB_i - NPC_i$$

Or, equivalently if

BRC_i = Benefit—Cost Ratio

$$NPB_i/NPC_i > 1 \tag{3}$$

Similarly, project j is economically preferred over project i if:

$$NPV_j > NPV_i$$

To obtain the general present value PV of total benefit TB, then subtract TC from TB to get Net Present Value NPV and could be obtained for the project evaluation.

4 Results and Discussion

4.1 Cost Estimation

The cost composition of a transport project can be primarily separated into costs related to the transport infrastructure and expenses related to working expenses. Infrastructure costs include investments in building and energy supplying and consumption, train scheming and traffic management systems and apparatus. Maintenance costs include labor costs, materials, and spare parts [21], cost evaluation of Ankara-Sivas high speed rail project is detailed below.

(1) *Transport infrastructure cost*

The transport infrastructure costs of a new HSR project include cost of setting up, land and building [21]. The cost of Infrastructure forms up to 50% of the whole cost [5], the construction phase of the Ankara-Sivas high speed rail project is ten years, the total infrastructure cost is 0.2712 billion) and the rest costs of construction and building C_i take up 88% ($1.9888 billion), the cumulative present value of transport Infrastructure cost C_i is $2,260 billion.

(2) *Operating costs*

Ankara Sivas high speed rail project consists of operating costs which include the costs of employment and power. Rus identified the working costs of HSR services to be per seat per year about $67,840.16, by assuming 8250 passengers seats in service then $559.68 million each year. cost of maintenance is expected about per km per year$40,742.64 [5], then the annual infrastructure maintenance cost C_{o1} is $16.54 million in 406 km length. The cost of rolling stock maintenance cost is $5,432.35 per seat per year, the annual maintenance cost C_{o2} is $44.82 million. The cumulative PV of working cost is $9,345.25 million.

(3) *External cost*

Creation of the high speed rail and using railway will bring damaging ecological impacts such as of land recommencement, barrier impacts, noise, and pollution. According to Rus the external cost of each 1000 passengers per km is equivalent to $14.13 per year [5], with 8250 passengers travelling between Ankara and Sivas by using this 406 km length line per day C_e of this project is about $0.09 million.

4.2 Benefits Evaluation

Journey time, pollution decreasing, dependability, and safety improvement are others profits of the economic benefits of the HSR investment, this study will explain five main types of social and economic benefits.

(1) *Tickets revenue*

According to the TCDD (2016) the ticket price of Ankara and Sivas high speed rail will be for most of the passengers with an average price of \$27.4. As a result, 8250 passengers will travel between Ankara and Sivas using high speed rail each day, the annual ticket revenue B_{tr} of Ankara and Sivas high speed rail will reach \$ 82.50 million.

(2) *Travel time savings*

Traveling time savings consists of outlet time, and waiting time De Rus confirmed if the mode of transportation is a usual railway operating under 100 km per hour speed, high speed rail will keep around forty five to fifty minutes for distance three to four hundreds km [22]. Ankara and Sivas high speed rail with the conventional railway assuming that they both have similar circumstances of access, outlet and waiting the journey high speed rail will keep about 90 min and the average rate of traveling time is equivalent to \$ 17.11 per passenger per hour with supposition of the traffic work of fifty percent commerce journeys, thirty percent commuting journeys and twenty percent other journeys [23]. So the travel time savings B_{ts} could result as \$77.29 million.

(3) *Pollution reduction*

High speed rail uses a sustainable and environmentally friendly skill, the carbon emission of high speed rail is just fifteen percent of planes and twenty five percent of transport on land; in addition, HSR could decrease the air pollutants by 1282 tons of NOx and 341895 tons of CO2 per year [24], the average rate of pollution reduction in CO2 and NOx emissions is \$33.95 per ton and \$7,741.10 per ton. As a result, pollution reduction B_{pr} is about \$ 21.54 million.

(4) *Reliability improvement*

HSR can effectively progress the reliability(B_{ri}) rank by avoiding overcrowding and delays and HSR has special reliability improvements compared to highway and conventional railway [25]. The rate of reliability enhancement (B_{ri}) is related to of value of traveling time savings, which is about 13.7%. Consequently, the annual benefit of B_{ri} is \$10.59 million.

(5) *Safety improvement*

High speed rail could help reduce traffic causalities and injuries of accidents. The rate amount of traffic causalities and injuries is expected to reduce by fourteen percent [5]. Social life loss caused by transport accidents are linked with the real gross domestic product. In 2017 real gross domestic product per capita of Sweden is \$ 56935.19 while real gross domestic product in turkey per capita is \$ 10597 [26]. As a result, the value of traffic causalities and injuries reduction and life-saving can be predictable on the basis of recommended Swedish valuations 18.64%, that is

$ 2.54 million per statistical life saved, $ 0.45 million per avoided serious injury and $ 0.02 million per avoided slight injury [25]. According to TCDD (2016), the annual number of traffic causalities, serious injury and slight injury on the highways are 270, 8242 and 25819 respectively. Consequently, the annual of B_{si} is about $ 687.55 million.

4.3 Clarification the Results

Based on the result above and for deep analysis to investigate whether Ankara Sivas high speed rail project should be carried out, and identify the current situation, the following techniques data analysis involved the data compilation which includes, cumulative present value of whole cost, cumulative present value of total social benefits and net present value NPV of high speed rail.

(1) *Cumulative present value PV of total cost Ankara Sivas HSR Project*

The cumulative PV of C_i is $ 2,260 million, the total cumulative PV of C_o is $ 9,345 million, and the cumulative PV of C_e is $ 1, 36 million. Then the cumulative PV of TC of the Ankara-Sivas project is equivalent to the sum of Infrastructure cost C_i, Operating costs C_o and External cost C_e, can be worked out as USD$ 12,965 billion as follows:

$$TC = \sum_{t=1}^{n} \frac{C_0 + C_i + C_e}{(1+i)^t} \tag{4}$$

i: the social discounting rate at highest level of inflation (0.06) in turkey, 15.046 social discounting rates is applied.
t: the number of operation years.
n: life expectancy of the project is 40 years.

(2) *Cumulative present value PV of social benefits Ankara-Sivas HSR Project*

Then the cumulative PV of total social benefits of the Ankara-Sivas HSR project is equivalent to adding up benefit of ticket profits, benefit of journey time, benefit of pollution reduction, benefit of reliability enhancement and benefit of Safety enhancement can be worked out as $ 13,323 billion by using the following function:

$$SB = \sum_{t=1}^{n} \frac{B_{tr} + B_{ts} + B_{pr} + B_{ri} + B_{si}}{(1+i)^t} \tag{5}$$

(3) *Net present value NPV of Ankara-Sivas HSR*

NPV of high speed rail is equivalent to the cumulative discounted PV of TSB, $ 13,323 billion minus the cumulative discounted PV of TC, $ 12,965 billion.

$$NPV_i = NPVB_i - NPVC_i$$

4.4 Sensitivity Analysis

To weigh up the strength of the outcomes we can use sensitivity analysis as an important tool for credibility. So many methods to test the sensitivity analysis of CBA. Applying method of Sensitivity in this study to identify the potential effect by addition or leaving out of one or more variables from the functioned method [27]. This method suggests that the research data is accurate and have Reliability and validity, and then we increase or decrease one or more variables to examine new outcomes. Applying this method by eliminates individually variable, the efficiency outcomes of decision making units will either stay unaffected or reduce but never will it raise [27]. Many factors of high speed rail project are crucial factors and influence in life circle of projects such as services operating cost, rolling stock maintenance cost, and traveler flow factors which have effect on the net present value. The operating cost is possibly to be affected and the identification of sensitivity analysis of services operating cost is important, by changing the range between −5–+5% with an interval of 2, 5%, Table 2 shows that the net present value changes from −132.4–+132.4%, and when Cs increases by 4%, the NPV decreases to zero.

For the total benefits, the ticket revenue and travel time savings are crucial factors for traveler flow per day and have impact on the income of high speed rail project. So, they play important role, net present value is expected with every change of passenger amount by 5, 10, 15% in the range of −15–+15%. It reveals that the net present value will always be positive till the passenger amount reduces by 14.5% Table 3.

Table 2 Sensitivity analysis of the influence of changes in operation cost on net present value

Change (%) in operation cost	Actual value	Total cost	NPV	Change in NPV (%)
−5	589.988	12,491	0.832	132,4
−2.5	605.514	12,725	0,598	67
0	621.04	12,965	0,358	0
2.5	636.566	13,192	0,131	−67
4	645.88	13,323	0	−100
5	652.092	13,426	−0.103	−132,4

Table 3 Sensitivity analysis of the influence of changes in passenger flow on net present value

Change (%) in ticket revenue and travel time savings	Actual value of ticket revenue and travel time savings	Total social benefit	NPV	Change in NPV (%)
−14,343	142.0107403	12,695	0	−100
−10	149.211	13,073.3	0,107.7	−69.8
−5	157.5005	13,198	0,233	−34,5
0	165.79	13,323	0,358	0
5	174.0795	13,447.50	0,481.5	34,5
10	182.369	13,573.2	0,608	69,8

5 Conclusion

This study investigated the various impacts of new high speed corridor investment on new towns. Ankara Sivas high speed rail project has been analyzed by using Cost-Benefit Analysis method. Ankara Siva high speed rail project turns out to be profitable in the circumstances analyzed and many social benefits can be earned. The study was fulfilled that Ankara Sivas high speed rail project has an efficient value for passengers in willing to live in new towns and expected to create positive value in the transportation sector, although high speed rail project has been serving a limited number of cities in turkey, but it is expected to improve by better accessibility, and have a better chance to attract and create new towns.

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Research on Risk Allocation of High-Speed Rail PPP Project Based on Bank Perspective

Xing Yang

Abstract PPP has become one of the important ways to finance high-speed rail projects, and banks will play an important role in this regard. Based on the role of banks in high-speed rail PPP projects and risk factors in the project process, this paper constructs the risk allocation process of high-speed rail PPP projects from the perspective of banks. Finally, a two-stage game model with incomplete information is constructed, and the optimal risk-bearing ratio is obtained.

Keywords High-speed rail · PPP project · Risk allocation · Mechanism · Commercial bank

1 Introduction

With the large-scale construction of railway in China, the drawbacks of railway investment and financing system are increasingly apparent. Problems such as single financing mode, high pressure of debt service and interest payment, and low efficiency of asset operation are gradually exposed. PPP model has become an important way of financing high-speed railway projects, in which Banks play an important role. However, in practice, the specialty of PPP model and the particularity of high-speed railway projects will result in numerous and complex risk factors of high-speed railway PPP projects. Therefore, the risk assessment and risk allocation of such projects is of great importance to the performance evaluation and goal realization of the whole project, which is also the focus of current government departments, social capital and financial institutions. As an important fund provider of the PPP model, banks are more cautious in controlling risks. How to promote and establish a standardized PPP risk sharing mechanism is of great significance for achieving a win-win situation.

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2 Literature Review

The researches on PPP risk issues by scholars from various countries mainly focus on three aspects including risk identification, risk assessment and risk allocation under the PPP model.

2.1 Foreign Research Review

Grimsey believes that the common risk-allocation decision-making process is mainly based on experience and subjectivity. Selecting balanced risk allocation turns expert knowledge and experience into a more usable research system, using fuzzy logic to analyze balanced development risk allocation. The research model combines the AHP analysis method to evaluate the ability, so as to determine the risk allocation with the best configuration [1]. Taking PPP projects in the transportation industry as an example, Medda analyzed the final offer arbitration between the public sector and private enterprises with the game theory method, and proposed the optimal scheme for the risk allocation between the two parties. The results of model analysis show that when the guarantor holds higher value than the financial loss, the game participants will face the problem of strategic behavior and potential moral hazard [2]. Chohra et al. pointed out that PPP is a contract between the public and private sectors to build and manage projects that provide public services. Among them, the most significant risks focused on the cost, quantity and construction period of the project should be shared between the public and private sectors [3]. Humpherys et al. and others suggested that in order to increase the financial viability of the project, the government often gave up the right to benefit. In this case, when the risk loss exceeds the pre-specified private sector tolerance, the government will bear the excess loss, but when the income exceeds the corresponding range, the government will give up the corresponding excess return to encourage the private sector to improve operational efficiency [4].

2.2 Domestic Research Review

From the domestic point of view, Li and Benshan identified the financing risks of railway PPP projects from the aspects of systemic risk and non-systematic risk, and from the perspective of the risk allocation body of the railway project, the government private enterprises, project creditors (banks and other financial institutions), project contractors, and operators after the completion of railway projects are the main risk bearers of railway project under the PPP financing model. On this basis, the risk assessment model is established by using the method of analytic hierarchy process and fuzzy mathematics. The problem of risk allocation mechanism among participants of railway construction projects under the PPP financing model in China is analyzed and the PPP financing model is designed. The risk allocation system for the railway construction project [5]. Gao and Kairong focused on the risk of major infrastructure projects, and summarized the characteristics and evolution mechanism of project risks. The risk assessment methods for major infrastructure projects were divided into four categories, including mathematical methods and game methods [6]. Li and Zhang analyzed the game process of financing companies, financial institutions and the government in PPP project. The tax rate and subsidy level are set by the government for PPP project participants, the degree of investment is set by enterprises and financial institutions. The information asymmetry risks in the situation are all important factors affecting PPP projects [7]. Chen In the high-speed rail PPP project, the government department and social investors reasonably share the risk and carry out the appropriate risk transfer mechanism, so that the risk of both parties pursuing the project is minimized, so that they can bear the most controllable risks. Reduce project costs while improving project efficiency [8].

2.3 Summary Review

Based on the above research and analysis at home and abroad, the summary is as follows. Firstly, the existing research only focus on risk sharing between the government and enterprises, ignoring the role of bank participation in PPP projects that improve the contract rate, provide loans, financing and other financial services. Thus, the risk allocation of banks participating in PPP project is not taken into account. Secondly, the theoretical research on bank risk management in academic circles is more thorough, and the analysis of risk source, risk sharing, risk prevention and so on is also more in-depth. However, when the country vigorously promotes the PPP project, there are still a few scholars who study the risk of banks participating in the PPP project, which is not conducive to the improvement of bank risk management, and it is an urgent area to study. Finally, through the analysis of previous studies, we can find that the proportion of quantitative research is relatively small. Most of the domestic scholars' research on PPP projects is still in the qualitative research. Therefore, on the basis of summing up the previous research, this paper intends to study how to share the financing risks among the three from the perspective of banks, and combine qualitative research with game analysis in order to obtain reasonable measures to prevent the financing risks of banks.

3 The Role of Bank and Risk in PPP Projects

Firstly, it is necessary to clarify the role of the bank in PPP projects, and then explore the risks that banks may encounter throughout the project.

3.1 The Main Way of Banks Supporting High-Speed Rail PPP Projects

- Consultation services in the early stage of the project. The high-speed rail PPP project covers financial, legal, engineering and other fields, such as planning, construction, operation and management, including price setting, cash flow assessment, income distribution, financial subsidy calculation, etc. Consulting services such as contract formation, project financing plan design and project evaluation. Banks can take advantage of their financial, accounting, and legal expertise to directly provide consulting services for high-speed rail PPP projects.
- Providing credit support in the construction period of projects as well as intermediary business such as entrusted loans and financial leasing.
- During the operation period of the project, banks can provide innovative businesses such as asset securitization, project income bonds, and factoring financing.
- In social capital withdrawal period, banks can provide services such as M&A financing support and equity transfer.

3.2 Risk Factors Faced by Banks in High-Speed Rail PPP Projects

From the perspective of risk sources, this paper divides PPP project risks into three levels: macro risk, meso risk and micro risk.

- The macro-level risks mainly involve risk events caused by some exogenous variables such as political policies, economic environment, legal policies, and environmental issues, which easily affect the project implementation process and performance evaluation.
- The meso-level risk reflects a risk that occurs and results within the system boundary of the project, mainly related to the risks in the refinancing, design, construction, operation and other phases of the project life cycle, which are caused by endogenous variables. Risk events, including project feasibility factors, design issues, engineering quality and technical factors.
- The micro-level risk is also the risk caused by the internal factors of the project, but it is different from the focus reflected by the micro-level risk. The micro-level risks mainly reflect the incompleteness of the parties (government departments, private institutions and commercial banks) based on the limited rationality of people and contracts, and each has different interests, and the risks arising from the mutual coordination of the stakeholders.
- The internal risk of the bank refers to the risk in the construction and operation of the high-speed rail PPP project due to the commercial bank's own reasons.

3.3 Bank's Risk Allocation in High-Speed Rail PPP Projects

There are many risk factors for the high-speed rail PPP project. How does the bank share these risks? The risk identification and evaluation in the risk allocation process of PPP project studied in this paper involves the project bidding stage; the initial risk allocation is for the contract organization stage, and the government department and the private sector negotiate the risk allocation ratio until an agreement is reached and a franchise contract is established. The important basis for the risk-allocation clause is that the risk-allocation supervision is carried out during the implementation of the project after the two parties sign the cooperation agreement. The government supervision department monitors and tracks the initial risk allocation to find out the risk factors that were not considered.

The first phase is mainly for risk identification and evaluation. On the basis of the necessity and feasibility of investigating project implementation, the government departments normally screen out the key risk factors of the PPP project according to the previous PPP project experience and expert consultation to construct a reasonable risk indicator system. The risk assessment method evaluates the probability of occurrence of each risk factor, the degree of loss that may be caused, the correlation among risk factors, and the management cost. From the perspective of risk influencing factors, effective risk prevention measures are proposed to minimize the probability of occurrence of risks and reduce the degree of risk loss. The purpose of assessing the risk is to judge whether the project is suitable for adopting the PPP model which is also the basis for selecting bidders and a precondition for the next stage of risk allocation.

The second stage is the determination of the initial risk allocation plan. Based on the risk identification and risk assessment of the PPP project in the previous stage, the government will prepare for the next phase of risk allocation and determine which party should control the risks, or share the risks based on the feasibility study. In this process, both parties should judge whether they have the risks controlling ability, the necessary management skills, and the corresponding cost of controlling risks, and the cost-benefit trade-offs. The government departments will retain some of the risks and transfer the remaining risks to private sector. The private sector decides whether to bear these risks based on an assessment of control capabilities and cost of ownership, and proposes a corresponding risk compensation price. Therefore, the main task is to determine which risks are borne by the government, which are borne by the private enterprises, and which risks are shared by both parties. The negotiations continue until the parties agree on the risk allocation plan, otherwise the negotiations will continue.

The third stage is the stage of government supervision of risk allocation, which is mainly the monitoring, tracking and redistribution stage of risk allocation by government regulatory authorities. At this stage, the government regulatory department itself or the entrusted intermediary agency should supervise the initial risk allocation of the second phase, so as to realize the risk allocation monitoring and tracking of the PPP project, reflecting the problems of risk allocation. Due to the long franchise cycle of

PPP projects, complex and variable risk factors will be encountered in the construction, operation and maintenance phases. Generally speaking, risk allocation cannot be completed at one time, and dynamic monitoring should be carried out throughout the life cycle of PPP projects. According to the risk control ability and management cost of each party, it is evaluated whether the risk allocation ratio is reasonable and whether the transferred risk is effective, whether the transferred risk is transferred again, and whether the risk allocation model and technology are effective.

4 Risk Allocation of High-Speed Rail PPP Projects Based on Game Theory

In the process of construction and implementation of the high-speed rail project, since there is a principal-agent relationship between the government, enterprises and construction companies, and there is cooperation and competition between the government, enterprises and construction companies, information will inevitably arise. The asymmetry has caused the government to pay more supervision and transaction costs for the smooth progress of the high-speed rail project, which will increase the construction cost and risk of the high-speed rail project. Under this incomplete contract, the game of risk will be more cautious.

This paper assumes that the decision makers in the government, banks and private investors are all rational people. In the process of risk allocation, in order to maximize the benefits, they will spontaneously form an “alliance” with the other side, forming an “alliance” and mutual information exchange mechanism. Complementary advantages, stronger deterrence to third parties, and at this time for the third party is incomplete information. Through the game with third parties, the “Allies” take on less risk and gain more benefits. Afterwards, the “Alliance” sides negotiated a bargaining game to redistribute internal risks. Because high-speed rail PPP projects are generally initiated by the government, and various policies and information channels are more biased toward the government, the government has the highest status, the strongest deterrence, the second is the bank, and the weakest. In order to gain benefits, enterprises and banks form alliances with the government. Therefore, the risk allocation of the three parties in the PPP project is divided into two phases. The first phase is that the company and the bank form an “alliance” and the government rotates the bid, conducts a bargaining game, achieves equilibrium, and obtains a balanced solution; the second phase is “alliance”. Internal enterprises and banks carry out risk allocation and bargaining game. Finally, the optimal risk allocation ratio of the three parties is obtained.

Table 1 The first round of game parameters definition

Parameter	Implication	Relationship
δ_1	The consumption coefficient of the government department in the process of bargaining	$\delta_1 < \delta_2$
δ_2	The consumption coefficient of "Alliance" in the process of bargaining	
r_i	The share of risk that the government wants to transfer to the "Alliance" department during each round of bargaining	$r_i < k_i$
k_i	The share of risk that the government should have assumed	

4.1 Basic Hypothesis of the Model

Hypothesis 1: The PPP project participants "alliance" (enterprise A + bank B) and government Care rational people, and neither of them wants the negotiation to break down.

Hypothesis 2: Risks to be undertaken in PPP projects are independent of each other, and there is no or very little correlation.

Hypothesis 3: The information between government C and the "alliance" (A + B) is not interconnected, which is in the state of incomplete information.

Hypothesis 4: The initial value of each risk to be borne in the PPP project of high-speed railway is 1. For a certain risk, the government and the "alliance" jointly assume it. If the government assumes *ki*, the "alliance" assumes 1 − ki. Both sides then haggle over the proportion.

Hypothesis 5: Government C's position is relatively high, and government C makes the first offer.

4.2 Model Parameters

See Table 1.

4.3 Model Establishment

First round: The first risk-allocation scheme is proposed by the government. In this scheme, the government proposes that the proportion of risks it is willing to bear is k_1, and the proportion of risks taken by "alliance" is $1 - k_1$. The proportion of risks transferred by the government to "alliance" is r_1, that is, the proportion of risks taken by the government decreases r_1, and the proportion of risks taken by "alliance" increases r_1. Finally, the risks taken by government C and the "alliance" (A + B) are respectively:

$$C_1 = k_1 - r_1 \tag{1}$$

$$(A + B)_1 = 1 - k_1 + r_1 \tag{2}$$

C_1 is the risk proportion taken by the government, and $(A + B)_1$ is the risk proportion taken by the "alliance". If the "alliance" does not agree with the risk allocation proposed by the government, it enters the second round of bargaining and the "alliance" proposes the risk proportion.

Second round: The second risk-allocation scheme is proposed by the "alliance". The "alliance" proposed that the risk bearing ratio of the government should be k_2, and the "alliance" should be $1 - k_2$. The government forced the transfer of a certain proportion of r2 that it should have borne to the "alliance", and another negotiation led to certain negotiation losses for both parties, so the risk bearing ratios were respectively:

$$C_2 = (k_2 - r_2) \tag{3}$$

$$(A + B)_2 = \delta_2(1 - k_2 + r_2) \tag{4}$$

If the government does not agree to the risk apportionment, then the third round will be conducted and the government will propose the risk apportionment.

Third round: A third risk-allocation scheme was proposed by the government. In this scheme, the government proposes that the proportion of its own risks should be *k3*, that of the "alliance" should be *1 − k3*, and that the government shall deter the "alliance" to bear a certain proportion of its own risks, *r3*. In the end, the risk proportion of the two parties shall be:

$$C_3 = \delta_1^2(k_3 - r_3) \tag{5}$$

$$(A + B)_3 = \delta_2^2(1 - k_3 + r_3) \tag{6}$$

The game between the government and the "alliance" on risk taking will continue until the two sides reach an agreement on the proportion of risk taking and the negotiation ends.

4.4 Model Solving

Choose the third round for the infinite round of negotiations to reverse the initial point. If in the second round, the "Alliance" proposes that the proportion of risk assumed by the government is greater than the proportion of risk assumed by the government in the third round, the government does not agree with this risk allocation plan and the negotiations have to enter the third round. Because the longer the negotiations are dragged, the greater the risk is, the greater the negotiation loss for the "Alliance" than the government, so in order to avoid unnecessary negotiation losses, in the second round, the "Affiliate" proposed by the government should bear no more risk than the third round. The risks are assumed, and the proportion of risks that the "Alliance" themselves bear is still to a minimum. In the second round, the optimal risk allocation strategy for "Alliance" A + B is:

$$\mathrm{C}_2 = \mathrm{C}_3 \tag{7}$$

$$\delta_1(k_2 - r_2) = \delta_2^2(k_3 - r_3) \tag{8}$$

That is,

$$k_2 = \delta_1(k_3 - r_3) + r_2 \tag{9}$$

At this time, the risk ratio assumed by the "Alliance" A + B is:

$$(A + B)_2 = \delta_2[1 - \delta_1(k_3 - r_3)] \tag{10}$$

$$(A + B)_2 - (A + B)_3 = \delta_2[(1 - \delta_1) + (k_3 - r_3)(\delta_2 - \delta_1)] \tag{11}$$

Since, $\delta_2 > \delta_1 > 1$, $1 > k_3 > r_3 > 0$, so, $(A + B)_2 > (A + B)_3$, neither negotiation will drag the negotiation to the third round. The same push back to the first round of negotiations. If the first round of government proposes that the "alliance" bears a greater risk ratio than the second round "alliance", the first round of negotiations will break down and have to be dragged to the second round. Therefore, the risk-taking strategy proposed by the first round of the government should not only assume that the "alliance" bears the risk less than or equal to the second round, but also minimizes the risks assumed by itself.

In the first round, the optimal risk allocation strategy for "Alliance" A + B is:

$$(A + B)_1 = (A + B)_2 \tag{12}$$

$$1 - k_1 + r_1 = \delta_2[1 - \delta_1(k_3 - r_3)] \tag{13}$$

$$k_1 = 1 + r_1 - \delta_2[1 - \delta_1(k_3 - r_3)] \tag{14}$$

Since this game model is an infinite round bargaining model, and for the infinite bargaining model, whether it is the first round or the third round, the minimum share of bargaining is the same, so there is:

$$k_1 = k_3 \tag{15}$$

$$1 - k_3 = [(\delta_2 - \delta_2\delta_1) - (r_1 - \delta_1\delta_2 r_3)]/(1 - \delta_1\delta_2) \quad (16)$$

Here we set r_i as the constant r, and the equilibrium result of the risk of the government and the "alliance" is:

$$K^* = (1 - \delta_2)/(1 - \delta_1\delta_2) + r \quad (17)$$

$$1 - K^* = (\delta_2 - \delta_2\delta_1)/(1 - \delta_1\delta_2) - r \quad (18)$$

K^* indicates the government's nominal risk-taking ratio. Due to the high status of the government, using its deterrence to transfer part of its own risk of proportion r to the "alliance", the actual risk-taking ratio is $K^* - r = (1 - \delta_2)/(1 - \delta_1\delta_2)$, the stronger the government's deterrence, the greater the r, the greater the risk that the "Alliance" will bear. The actual risk ratios that the government and the "Alliance" actually bear are:

$$K^* = (1 - \delta_2)/(1 - \delta_1\delta_2) \quad (19)$$

$$1 - K^* = (\delta_2 - \delta_2\delta_1)/(1 - \delta_1\delta_2) \quad (20)$$

5 The Game Within the "Alliance"

It is assumed that before the "alliance" is formed between Banks and enterprises, the information and countermeasures of both sides are exchanged, so the game inside the "alliance" in the second stage is a complete information game.

5.1 Basic Hypothesis of the Model

Hypothesis 1: The information asymmetry between Bank D and Enterprise E is an incomplete information state.
Hypothesis 2: Banks and enterprises are rational and do not want negotiations to break down.
Hypothesis 3: The risks in the PPP project are independent of each other, and there is no or weak correlation.
Hypothesis 4: The sum of the risk-taking of the bank and the enterprise is k_i, ($0 < k_i < 1$), and the bank take k_i, the enterprise assumes $k_i - \alpha_i$, and both parties bargain.

Table 2 The second round of game parameters definition

Parameter	Implication	Relationship
ε_1	The consumption coefficient of the bank in the process of bargaining	$\varepsilon_1 < \varepsilon_2$
ε_2	The consumption coefficient of enterprises in the process of bargaining	
m_i	The risk share that the enterprise wants to transfer to the bank during each round of bargaining	$m_i < \alpha_i$
α_i	The share of risk that the corporate sector should have assumed	

Hypothesis 5: In the high-speed rail PPP project in China, the private investors introduced are large central enterprises, state-owned enterprises and private enterprises with strong voices. The enterprises are in a strong position and the enterprises are bidding first.

5.2 *Model Parameters*

See Table 2.

5.3 *Model Establishment*

In the game, enterprises and banks have more bargaining power and bidding options, and their status is higher than that of banks. Therefore, enterprises bid first.

Round 1: The first plan was proposed by the company. In this scenario, Enterprise D proposes to take the risk ratio of α_1. Bank E assumes a risk ratio of $k - \alpha_1$, $k = (1 - \varepsilon_2)/(1 - \varepsilon_1\varepsilon_2)$. With the higher bargaining position, the enterprise will take use of its own deterrent power to transfer some of its risk m_1 to the bank, then the ratio of each of the company D and the bank E is:

$$D_1 = \alpha_1 - m_1 \tag{21}$$

$$E_1 = k - \alpha_1 + m_1 \tag{22}$$

If the bank disagrees with the risk allocation strategy proposed by the company, the negotiation breaks down and enters the second round of negotiations, and the bank proposes a risk allocation plan.

Round 2: The second option was proposed by the bank. In this scheme, the bank proposes that the proportion of risk taken by the enterprise is α_2, and the proportion of risk assumed by the bank itself is $k - \alpha_2$, and the enterprise transfers its risk m_2 to the bank because of its dominant power.

The risk-to-risk ratios of Enterprise D and Bank E are:

$$D_2 = \varepsilon_1(\alpha_2 - m_2) \tag{23}$$

$$E_2 = \varepsilon_2(\mathrm{k} - \alpha_2 + m_2) \tag{24}$$

If the company does not agree to this risk allocation, the negotiations enter the third round.

Round 3: The third option was proposed by the company. In this scheme, the company proposes that the risk ratio of its own risk is α_3, the risk assumed by the bank is $k - \alpha_3$, and the risk of the enterprise forcibly transferring m_3 to the bank by its deterrence, the risk-to-capital ratio of enterprise D and bank E are:

$$D_3 = \varepsilon_1^2(\alpha_3 - m_3) \tag{25}$$

$$E_3 = \varepsilon_2^2(\mathrm{k} - \alpha_3 + m_3) \tag{26}$$

5.4 Model Solving

The third round of cooperation that selects the limited round is the initial node of the inverse round of the infinite round negotiation. If the risk ratio of the second round of the enterprise is greater than the proportion of the risk assumed in the third round, the company disagrees with the risk allocation plan of the second round, and the negotiation breaks down and has to enter the third round. Because the longer the negotiation drags, the greater the risk, the negotiation loss of the bank is greater than the negotiation loss of the enterprise, so in order to avoid unnecessary negotiation loss, the risk that the bank proposes should be no more than the third round. The risk, and the proportion of risk that the bank itself bears must be minimized.

In the round 2, Bank E's optimal risk allocation strategy is:

$$D_3 = D_2 \tag{26}$$

$$\varepsilon_1^2(\alpha_3 - m_3) = \varepsilon_1(\alpha_2 - m_2) \tag{27}$$

$$\mathrm{A}_3 = \varepsilon_1(\alpha_3 - m_3) + m_2 \tag{28}$$

At this time, the risks borne by the company are:

$$E_2 = \varepsilon_2[\mathrm{k} - \varepsilon_1(\alpha_2 - \mathrm{m}_2)] \tag{29}$$

$$E_2 - E_3 = \varepsilon_2[k(1 - \varepsilon_2) + (\varepsilon_1 - \varepsilon_2)(m_3 - \alpha_3)] \tag{30}$$

Because:

$1 < \varepsilon_1 < \varepsilon_2, 0 < m_3 < \alpha_3 < 1$, so $E_2 - E_3 < 0$, neither will drag the negotiation to the third round.

In the round 1, if the company proposes that the risk assumed by the bank is greater than the risk assumed in the second round, the bank does not agree with the risk allocation plan of the enterprise, and the negotiation has to be dragged into the second round. Therefore, in order to reduce the loss of negotiation, in the first round, the company proposes that the risk assumed by the bank is less than or equal to the risk assumed by the bank in the second round, and at the same time the risk is minimized, the negotiation can be terminated in the first round. Therefore, the optimal strategy for Enterprise D in the first round is:

$$\varepsilon_2[k - \varepsilon_1(\alpha_3 - m_3)] = k - \alpha_1 + m_1 \tag{32}$$

$$\alpha_3 = (k + m_1 - \varepsilon_2 - \varepsilon_1\varepsilon_2 m_3)/(1 - \varepsilon_1\varepsilon_2) \tag{33}$$

Since this game model is an infinite round bargaining model, for the infinite bargaining model, the minimum share of bargaining is the same no matter it is the first round or the third round, so there is:

$$\mathrm{A}_1 = \alpha_3 \tag{34}$$

$$\alpha_1 = k + m_1 - \varepsilon_2[k - \varepsilon_1(\alpha_3 - m_3)] \tag{35}$$

Assume $m_i = m$, the risk-balanced result of the company and the bank is:

$$\mathrm{A}^* = (k - \varepsilon_2)/(1 - \varepsilon_1\varepsilon_2) + m \tag{36}$$

$$k - \alpha^* = \varepsilon_2(1 - \varepsilon_1 k)/(1 - \varepsilon_1\varepsilon_2) - m \tag{37}$$

As the company is in a strong position, it uses its lead to transfer part of its own risk to the bank, and the actual risk-taking ratio is $(k - \varepsilon_2)/(1 - \varepsilon_1\varepsilon_2)$. According to the bargaining result (19) of government and the "alliance" in the first stage, about risk allocation, the sum of the risk ratios of the bank and the enterprise is $K^* = (1 - \delta_2)/(1 - \delta_1\delta_2)$, so the K The specific expression substitution (36) (37) can be used to obtain the final actual risk-to-risk ratio between the enterprise and the bank. The final actual risk-to-risk ratio between the enterprise and the bank can be:

$$[(1 - \delta_2) - \varepsilon_2(1 - \delta_1\delta_2)]/[(1 - \delta_1\delta_2)(1 - \varepsilon_1\varepsilon_2)] \tag{38}$$

$$[\mathrm{E}_2(1 - \delta_1\delta_2 - \varepsilon_1\delta_2)]/[(1 - \delta_1\delta_2)(1 - \varepsilon_1\varepsilon_2)] \tag{39}$$

6 Conclusion

Reasonable risk allocation is the basis of the project cooperation framework and a prerequisite for the parties to form a win-win concept. Based on the bargaining game theory under incomplete information, this paper constructs a PPP project risk allocation ratio model considering the different bidding sequences of participating entities and studies the impact of bidding order on risk allocation results, and explains the risk allocation game in PPP projects. After two stages of risk-allocation bargaining game, the risk ratios of the government, enterprise and bank in the high-speed rail PPP project are:

Government:

$$(1 - \delta_2)/(1 - \delta_1\delta_2) \tag{40}$$

Enterprise:

$$[(1 - \delta_2) - \varepsilon_2(1 - \delta_1\delta_2)]/[(1 - \delta_1\delta_2)(1 - \varepsilon_1\varepsilon_2)] \tag{41}$$

Bank:

$$[\varepsilon_2(1 - \delta_1\delta_2 - \varepsilon_1\delta_2)]/[(1 - \delta_1\delta_2)(1 - \varepsilon_1\varepsilon_2)] \tag{42}$$

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Factors Influencing Sustainable Development of Real Estate

Yang Li and Xu Ren

Abstract This paper takes the influencing factors of real estate's sustainable development as the research object, by selecting 8 indicators from social conditions, economic conditions and environmental conditions to construct a binary relationship diagram between indicators. Based on the systematic review of relevant literature and theoretical analysis, the Interpretative Structural Modeling (ISM) is used to explore the hierarchical logical relationship between the influencing factors, as well as the influence path and influence degree of each influencing factor are. The results show that the influencing factors are divided into three sub-levels: the surface layer (direct impact layer), the intermediate layer (indirect impact layer) and the deep layer (basic layer). The surface layer is the economic benefits of the real estate industry, the intermediate layer is the market factor, and the deep layer refers to the resource, population and policies. These have further clarified the influencing mechanism at all levels to promote the sustainable development of the real estate industry. Based on the results of the hierarchical division and the influencing mechanism, suggestions for promoting the sustainable development of the real estate industry are put forward.

Keywords Interpretative Structural Modeling · Sustainable development of real estate · Influencing factors · Hierarchical structure

1 Introduction

The essence of sustainable development of real estate is to meet the various needs of contemporary people and future generations for real estate, and to coordinate the development of real estate industry with ecological resources and social economy. The concept of sustainable development was first proposed in 1987. Since then,

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scholars at home and abroad have done a lot of research on the sustainable development of real estate. For example, Abidin N Z and Yusof N have studied the contributing factors for creating a viable environment for the sustainable residential industry, and explored the obstacles to this progress. They maintain that the four driving factors for the sustainable development of the real estate industry are technology, institutions, internal actions and market influence. Shuangfei Xu believes that the factors affecting the development of the real estate industry are resources, stocks and uncoordinated cooperation between industries. Based on the ISM model, this paper conducts in-depth research on the factors influencing the sustainable development of real estate, such as population, policy, economy, and resources.

2 Literature Review

2.1 Status of Foreign Research

Many foreign scholars have proposed many creative theories on the sustainable development of real estate. Hansen and Coenen have studied the real estate housing market in the United States and the geography of sustainable transformation, applied the development cycle of the residential market and the national economy, and reviewed the theory of sustainability [1]. Kaisers has further studied the real estate cycle according to different stages of real estate development [2]. Geiger and Cajias M's research is in its infancy, but in the past few years their research has become more attractive. The driving factors are technology, institutions, internal actions and market influence [3]. Winston researched sustainable housing with relatively low density of indicators such as land use and public transport development, and proposed the concept of "regeneration: sustainable communities" [4].

2.2 Status of Domestic Research

The essence of the theory of sustainable development means that the consumption of various "resources" must satisfy the needs of modern people without compromising the ability of future generations. As for the application of sustainable development theory in the real estate industry, some domestic scholars have conducted a lot of empirical research.

Xu researched that the factors affecting the development of the real estate industry are resources, stocks and uncoordinated cooperation between the industries, especially the lack of funds for financial institutions [5]. Wang and Xiao discovered through research, firstly, the facilities such as the pipe network and the supporting facilities around the real estate should be sound, the second is to protect the ecological environment during the construction process; and the third is to use the policy inclination to promote the coordinated development of real estate in the country [6].

The real estate industry sustainable development index evaluation system was also established. Among them, Zheng' s research on real estate industry started from different angles, and used the analytic hierarchy process to establish a real estate industry sustainable development index evaluation system for economy, population, environment, resources and society [7]. Yin and Chu also selected the relevant influencing factors, established the real estate industry's sustainable development index system, built the efficacy function and assessed the level of sustainable development [8].

Different scholars have different understandings of the sustainable development of real estate. Based on the connection between the development of the real estate market and the growth of the population, Wu further pointed out that real estate has an important industrial status in the national economy and believes that the real estate industry has a greater contribution [9]. Lin pointed out that the real estate industry is sustainable [10]. First, it meets the needs of the present generation and its descendants for housing, including the rational use of land resources, the stable and healthy development of the housing industry, the improvement of the real estate market and the improvement of residents' quality of life. Second, while the real estate industry itself is constantly developing, it must be coordinated with economic, social and ecological resources.

As can be seen from the above review, domestic scholars define sustainable development of real estate as meeting the needs of contemporary people and future generations for real estate, and improving the real estate industry and ecological resources, social economy and other coordinated development from the economy and society. Based on the influencing factors of resources, environment and population, the evaluation index system of sustainable development of real estate industry is constructed. Finally, based on the evaluation results of sustainable development of real estate industry, relevant countermeasures are given.

3 Analysis of Influencing Factors

3.1 Influence Factors

In order to ensure the quality and quantity of the literature, this paper finally determines the journals in CSSCI as the search object based on the scientific and comprehensive principles of index selection. In terms of the social conditions, economic conditions and environmental conditions that affect the sustainable development of real estate, 5 papers and 8 specific indicators of sustainable development influencing factors were selected. Table 1 shows the list of influence factors of real estate sustainable development.

Table 1 Influence factors

Si	Factor	Reference
S1	Population	[8]
S2	Government policy	[9]
S3	Macroeconomic environment	[10]
S4	Economic benefits of the real estate industry	[10]
S5	Existing market conditions	[10]
S6	Residents' purchasing power	[9]
S7	Resource condition	[9]
S8	Urban supporting facilities	[9]

(1) *Social conditions*

(a) *Population:* As the population grows and the urbanization process accelerates, it is necessary to study the relationship between the real estate industry and the population. The population, population quality, population structure and population distribution will all have a major impact on the sustainable development of real estate.

(b) *Government policies:* it includes real estate supply policies, housing allocation and consumption policies, real estate financial policies, real estate property rights and trading policies, and real estate price policies. The reform of the housing system has brought historic opportunities for the development of the real estate industry and laid a solid foundation for the sustainable development of the real estate industry. Changes in policies and regulations will directly affect the development of the real estate industry. Therefore, establishing a sound real estate system and promoting the standardized and orderly development of the real estate market will be conducive to the sustainable development of the real estate industry.

(2) *Economic conditions*

As a basic of leading and pillar industry of the national economy, and an important part of the national economy, the real estate industry's development plays an important role in economic development, and the development of the entire national economy will provide necessary condition and motivation support for the sustainable development of the real estate industry. The downturn in the development of the national economy will have serious constraints and constraints on the development of the real estate industry. Conversely, the sluggishness of the real estate industry will also hinder the healthy development of the national economy. The two are interrelated and mutually restrictive.

(a) *Macroeconomic environment:* The real estate industry is one of the pillar industries. Real estate is the basic production factor, and the real estate market is an important part of the market system. With the continuous development of the national economy and the continuous adjustment of the industrial structure, a country requires the allocation and re-allocation of land resources. Real estate must enter the market, which inevitably requires the formation of a developed real estate industry and a standardized real estate market.

(b) *Economic benefits of the real estate industry:* it refers to the construction industry's share of regional GDP, real estate development input-output ratio, real estate investment and loan dependence, real estate industry per capita profit rate. The economic benefit is the comparison of capital occupation, cost expenditure and output value. The so-called good economic benefits means less capital occupation, less cost and high output value. It is significant for the sustainable development of the real estate industry to improve economic efficiency.

(c) *Existing market conditions:* it refers to the existing housing completion area, sales area, new construction area, real estate price, commercial housing vacancy rate, etc., which determines the degree of risk of investing in real estate.

(d) *Residents' purchasing power:* The more national wealth is accumulated, the higher the national savings rate, indicating that the more money the residents have, the more potential capital they use to buy real estate and invest in real estate, and the real estate market will inevitably increase. On the contrary, house prices fell. So far, the state of capital diverted from the national savings to the real estate market will become an important basis for predicting the real estate market in China.

In short, economic factors are important factors affecting the sustainable development of the real estate industry. We must correctly understand, analyze and use them to make them beneficial to the healthy development of the real estate industry.

(3) *Environmental conditions*

   (a) *Resource conditions:* The real estate industry must continue to develop and must be based on natural resources, including water, land, forests, atmosphere, oceans etc. This paper mainly studies the relationship between land resources and sustainable development of real estate. Environment and environmental protection are the guarantee for the sustainable development of real estate industry. If the environment is not protected, it will inevitably lead to the deterioration of human living conditions, and it is even more difficult to talk about the sustainable development of the real estate industry. Among the many resource conditions, real estate and land are most closely related. Land is the raw material of real estate, raw material prices are rising, and finished products are rising, so the land is directly proportional to the real estate market as land prices rise, house prices rise, and vice versa. In recent years, with the development of the economy, the land prices in various cities in China have risen sharply, so the house prices have also risen sharply.

   (b) *Urban supporting facilities:* Urban supporting facilities refer to physical engineering facilities that provide public services for urban production and residential life. It mainly includes six major systems, namely energy supply system, water supply and drainage system, transportation system, post and telecommunications system, and environmental sanitation handling system, defense and disaster prevention safety system. Urban construction provides the preconditions for the utilization of space and resources and the source of sustainable development for real estate operation. This is mainly reflected in the fact that urban development will inevitably bring about the expansion of urban scale, the improvement of urban construction quality and the soundness of supporting facilities, which also triggered sustainable urban renewal and sustainable development of the real estate industry.

3.2 Relationship Between Various Influencing Factors

This paper builds a binary relationship diagram by collecting expert opinions and literatures and using the eight influencing factors of sustainable development of real estate mentioned above. The influencing factors include: S1 (population), S2 (government policy), S3 (macroeconomic environment), S4 (real estate economic benefits), S5 (existing market conditions), S6 (residents purchasing power), S7 (resource conditions), and S8 (urban supporting facilities). The relationship between the influencing factors is shown in Fig. 1 (S1 and S3 at the node indicate that the node meets by S1 and S3 factors, and other nodes are the same). Although Fig. 1 shows the influence of various factors, it lacks hierarchical logic. It seems messy and clueless.

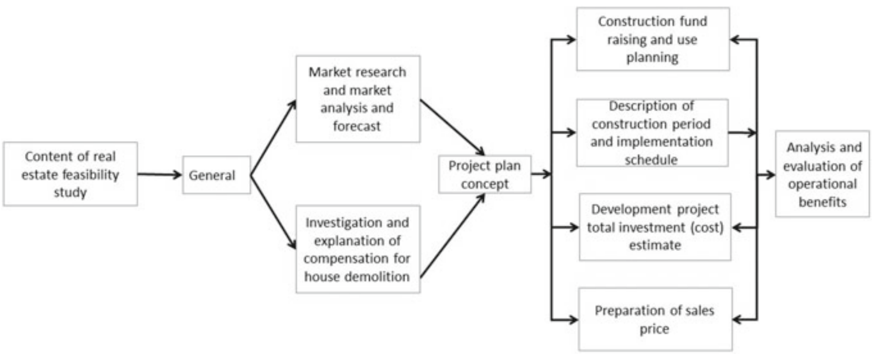

Fig. 1 The feasibility study process of a real estate project

4 Model Construction and Analysis

4.1 Introduction to the Model

First, the Interpretative Structural Modeling analyzes the relationship between various factors based on the selection of influencing factors; then it builds the adjacency matrix and calculates the reachable matrix from the adjacency matrix; next, it extracts the skeleton matrix according to the result of the series division. According to the relationship between the skeleton matrix and the factors, a multi-level hierarchical structure model of each factor hierarchy and relationship is prepared. The purpose of introducing the explanatory structure model is to transform the fuzzy relationship between the eight influencing factors into a well-structured and intuitive structural relationship model, which is convenient for analyzing the hierarchical logic. Therefore, this model is especially suitable for system analysis with many variables, complex relationships and unclear initial structures.

4.2 Model Building

The following steps should be followed in the modeling process. Firstly, based on the literature review of real estate sustainable development and the collection of expert opinions, a binary relationship matrix between different factors is established. Secondly, based on the binary relationship matrix results, an adjacency matrix is built. This is to characterize the causal relationship between different factors. Thirdly, depending on the adjacency matrix, a reachable matrix is set up to analyze the indirect relationship between different factors. Fourth, the index level is divided. Fifth, multi-level hierarchical structure model diagram based on sorting results is constructed.

(1) *Building a binary relationship matrix*

Through the collection of existing literature and expert opinions based on the scientific and comprehensive principles, this paper selects 8 specific effects from social conditions, economic conditions and environmental conditions to construct a binary relationship diagram. Influential factors include: *S1* (population), *S2* (government policy), *S3* (macroeconomic environment), *S4* (real estate economic benefits), *S5* (existing market conditions), *S6* (residents purchasing power), *S7* (resource conditions), *S8* (urban supporting facilities). When the row factor affects the listed factor, it is V; when the row factor affects the row factor, it is A; when the row factor and the column factor interact, it is X; when there is no influence on each other, it is O. The results are shown in Table 2.

(2) *Constructing an adjacency matrix*

The adjacency matrix A in this model consists of 0 and 1, and has 8 rows and 8 columns. Number 1 or 0 replaces symbols V, A, X or O to create reachability matrix.

Table 2 Binary relationship of influencing factors

	S8	*S7*	*S6*	*S5*	*S4*	*S3*	*S2*	*S1*
S1	V	A	V	V	V	O	X	
S2	V	A	V	O	O	V		
S3	X	O	V	V	V			
S4	A	O	O	A				
S5	O	O	X					
S6	O	O						
S7	O							
S8								

It is judged whether the value of a_{ij} is 1 or 0 according to the following conditions. If the factor S_i has a direct influence on S_j, then $a_{ij} = 1$, otherwise $a_{ij} = 0$; if S_j has a direct influence on S_i, then $a_{ji} = 1$, otherwise $a_{ji} = 0$. The equation mode is followed.

$$b_{ij} = \begin{cases} 1 & a_{ij} = V \\ 0 & a_{ij} = A \\ 1 & a_{ij} = X \\ 0 & a_{ij} = O \end{cases} \tag{1}$$

$$b_{ji} = \begin{cases} 0 & a_{ij} = V \\ 1 & a_{ij} = A \\ 1 & a_{ij} = X \\ 0 & a_{ij} = O \end{cases} \tag{2}$$

(3) *Calculating a reachable matrix*

Calculating $(A + E)\ k$ according to the logical algebra operation method. When $(A + E)\ k = (A + E)\ k{-}1$, the reachable matrix M can be calculated, where E is the identity matrix.

$$A = \begin{bmatrix} 0\,1\,0\,1\,1\,1\,0\,1 \\ 1\,0\,1\,0\,0\,1\,0\,1 \\ 0\,0\,0\,1\,1\,1\,0\,1 \\ 0\,0\,0\,0\,0\,0\,0\,0 \\ 0\,0\,0\,1\,0\,1\,0\,0 \\ 0\,0\,0\,0\,1\,0\,0\,0 \\ 1\,1\,0\,0\,0\,0\,0\,0 \\ 0\,0\,1\,1\,0\,0\,0\,0 \end{bmatrix} \tag{3}$$

$$M = \begin{bmatrix} 1&1&1&1&1&1&0&1 \\ 1&1&1&1&1&1&0&1 \\ 0&0&1&1&1&1&0&1 \\ 0&0&0&0&0&0&0&0 \\ 0&0&0&1&1&1&0&0 \\ 0&0&0&1&1&1&0&0 \\ 1&1&1&1&1&1&0&1 \\ 0&0&1&1&1&1&0&1 \end{bmatrix} \quad (4)$$

(4) *Dividing the indicator level*

The Reachable set ($R(S_i)$), the Advanced set ($A(S_i)$), and the Common set ($C(S_i)$) of each influencing factor can be obtained by the reachable matrix M. $R(Si)$ is a set of factors affected by *Si*, and A(*Si*) is a set of factors affecting S_i. When C(*Si*) is consistent with R(*Si*), the corresponding S_i is divided into the first level, then the rows and columns of the Si in the reachable matrix M are removed, and then the reachable set and the common set are continuously viewed. When C(*Sj*) is the same as R(*Sj*), the *Sj* at this time is divided into the second level. For the same reason, the series of all factors are divided until the end, and the results are shown in Table 3.

(5) *Drawing multi-level hierarchical structure model diagram*

The reachable matrix M and the series partition table are analyzed to obtain the structural model skeleton matrix. According to the skeleton matrix and the derived hierarchical relationship, a multi-level hierarchical structure model diagram is drawn (Fig. 2) by combining with the relationship between the influencing factors. Among

Table 3 Division of factors

Si	Influence factors	Reachable set R(Si)	Advanced set A(Si)	Common set C(Si)	Gradation
S1	Population	(1,2,3,4,5,6,8)	(1,2,7)	(1,2)	4
S2	Government policy	(1,2,3,4,5,6,8)	(1,2,7)	(1,2)	4
S3	Macroeconomic environment	(3,4,5,6,8)	(1,2,3,7,8)	(3,8)	3
S4	Economic benefits of the real estate industry	∅	(1,2,3,5,6,7,8)	∅	1
S5	Existing market conditions	(4,5,6)	(1,2,3,5,6,7,8)	(5,6)	2
S6	Residents' purchasing power	(4,5,6)	(1,2,3,5,6,7,8)	(5,6)	2
S7	Resource condition	(1,2,3,4,5,6,8)	∅	∅	5
S8	Urban supporting facilities	(3,4,5,8)	(1,2,3,7,8)	(3,8)	3

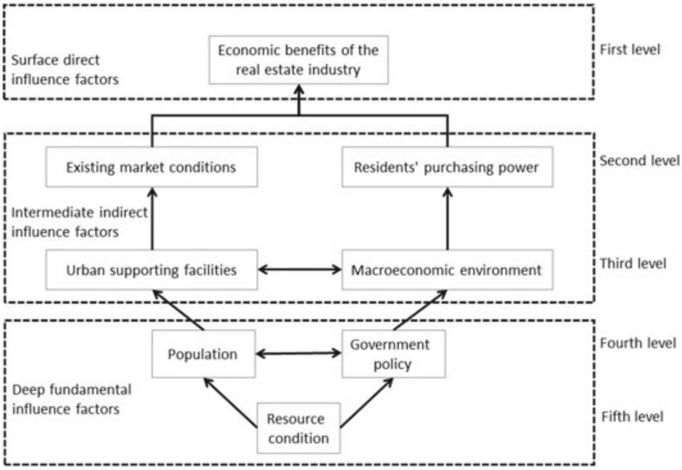

Fig. 2 Multi-level hierarchical structure model diagram

them, the upper layer can directly affect or pass the indirect conversion to affect the next level.

4.3 Analysis of Results

According to the hierarchical structure, it can be divided into five small series. After further analysis, the paper divides the five small levels into three major levels, and determines that the first level is the direct influencing factor of the surface layer, the second level and the third level are the indirect influencing factors of the middle layer, and the fourth and fifth levels reflect the logical relationship between each other.

The results of the hierarchical structure analysis of the model are as follows.

(1) *Surface layer*

Surface layer refers to economic benefits of the real estate industry. The surface factor is *S4* (economic benefits of the real estate industry). They are the most direct factors determining the sustainable development of the real estate industry. They are not only an effective basis for investment decisions in real estate's development projects, but also a decisive factor for developers and investors to decide whether to invest.

(2) *Intermediate layer*

Intermediate layer is also called intermediate indirect factors. It includes the second-level *S5* (existing market conditions), the *S6* (residents' purchasing power) and the third-level *S3* (macroeconomic environment) and the S8 (urban supporting facilities). Although the government directly or indirectly affects these factors, it

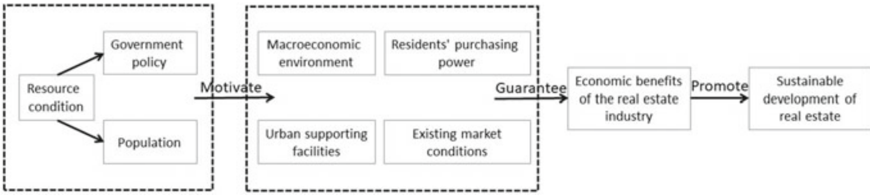

Fig. 3 Mechanism of action

cannot achieve efficient allocation of resources. These factors are more affected by the invisible hand of the "market." Today, when the policy is gradually open, the government is more decentralized in the market and supplemented by the market. Therefore, the middle-level influencing factors can be collectively referred to as the "market role layer".

(3) *deep layer*

Deep layer is also called fundamental factors. The deep influencing factors include the fourth-level *S1* (population), *S2* (government policy) and the fifth-level *S7* (resource condition). Resource conditions are the most basic factor for the sustainable development of the real estate industry. Areas with more favorable resource conditions and population have priority for better development with the support of government policies, mainly due to low development resistance, less overall investment, higher return on investment and future earnings.

5 Conclusion

5.1 Mechanism of Sustainable Development of the Real Estate Industry

In the past, the literature only analyzed the influencing factors affecting the sustainable development of real estate, but did not study the relationship between each factor. Through in-depth analysis of the multi-level hierarchical structure model of the influencing factors of sustainable development of real estate industry, this paper divides the influencing factors into layers, explores the mechanism of sustainable development of real estate industry, and provides a theoretical basis for further exploration of the sustainable development path of real estate industry. The mechanism of the sustainable development of the real estate industry affected by various levels of factors is shown in Fig. 3.

First of all, deep resource conditions are prerequisites for all development in line with population conditions, government policy's guidance, regulation, and supervision. Through the role of the middle layer market to promote the improvement of the macroeconomic environment and the improvement of urban supporting facilities, and thus promote the continuous improvement of the purchasing power of residents and the stability of the existing market conditions so as to ensure the maximum economic benefits of the real estate industry, and ultimately promote continuous development of the entire real estate industry. This mechanism reveals the main responsibilities of each level, indicates that the sustainable development of real estate needs to be promoted at all levels. All links work together and are indispensable.

5.2 Safeguard Path

Based to the analysis of the sustainable development of the real estate industry, it is necessary to start from the aspects of social, economic and environmental conditions in order to achieve sustainable development, and propose the following guarantee paths.

(1) *Establishing a market supervision system*

In terms of government policies, it is necessary to establish a supervision system for housing quality, improve the quality of housing, and reduce the emergence of vacant land and vacant houses. In addition, we must raise the threshold of the real estate industry, improve the laws and policies related to the real estate industry, and eliminate the phenomenon of "indiscriminate investment". We must focus on preventing corruption and establish a fair and reasonable market competition mechanism to create a fair, just, transparent and open market environment for the sustainable development of the real estate economy.

(2) *Establishing the real estate's financial system and improving the secondary market of real estate's finance*

A sound real estate financial infrastructure system not only provides a fundamental guarantee for the source of funds for real estate, but also has a high improvement in the efficiency of capital use. Establishing a sound secondary market for real estate finance can effectively improve the marketization process of real estate finance and reduce the risk of bank loans. On the other hand, it also accelerates the transformation of state-owned banks to commercial banks, which is conducive to improving the efficiency of real estate finance and improving the sustainable development of the real estate industry.

(3) *Improving resource utilization*

To continue to develop, the real estate industry must be based on natural resources. Natural resources include water, land, forests etc., and the scope is very wide. This paper mainly studies the relationship between land resources and the sustainable development of real estate. Land is a scarce and non-renewable resource, it is both a natural resource and a vital component in the development of the real estate industry. To this end, the government must firmly grasp the land resources, establish a monopoly state-owned land development company, and timely adjust the market supply of land according to changes in market conditions through direct control of state-owned land development companies, which is in line with the market economy. The intrinsic requirements have also realized the recovery of land-level difference income to the greatest extent, and provided solid financial and resource support for the sustainable development of China's urban construction.

The real estate industry has become an important pillar industry in China. Therefore, its regulation and management are very urgent. At the same time, the rapid development of China's real estate industry has also experienced many problems, resulting in more or less bubble crisis in China's current real estate economy. Therefore, in order to promote the development of China's real estate industry in a healthy and sustainable direction, we must strengthen norms and constraints from the social, economic, and environmental aspects, and promote China's real estate industry to follow the right path.

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Interpretive Structural Modelling of Factors Influencing Enterprise Transformation

Ming Bai and Xu Ren

Abstract In this article, nine influence factors of enterprise transformation are identified and analyzed. With the development of enterprise transformation activities, the nine factors become either the enablers or the obstacles. To explain the reason for choosing these nine factors, exhaustive literature review is done. With the help of expert opinions, influence factors are determined. ISM modeling is used to arrange these factors in order of priority. Result analysis shows that the influence factors for transformation practices can be divided into three categories: surface direct factors, middle dynamic factors and deep guiding factors. Main factors influencing enterprise transformation vary in different environments. The study shows that enterprise leadership group must have clear overview of the market environment and the industry environment, contrive definite intent and path, and guide to success.

Keywords Enterprise transformation · Interpretive structural modelling · Influence factor

1 Introduction

Enterprise transformation is a process of transforming industry, changing growth-pattern, and upgrading products. The aim is to transform low-end technology and low added value into high-end technology and high added value. Enterprise transformation is also a process of continuous change. It is the micro level and ultimate goal of industrial transformation and upgrading.

With economic expansion having moderated to a new normal pace, there are three challenges facing China, which is slowdown, optimization of economic structure, and transformation factor-driven and investment-driven into innovation-driven. In the

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new normal economy, the need for enterprise transformation is more realistic and urgent. Current performance of turning to the ends of Smiling Curve in enterprise value chain is not satisfying. Developing new business models and establishing a network platform are not easy. This is due to the lack of knowledge accumulation and the advanced thinking mode.

Successful transformation can improve the ability of continuous competition, increase the added value of products or services, and find new business and development direction. Though enterprise transformation brings potential benefits, Chinese enterprises do not know what promote the success of transformation. Therefore, it is important to seek and analyze the influence factors which drives the development of enterprise transformation.

Approaches which cause enterprise transformation are being explored and analyzed by researchers to ensure the existence and development of enterprises. The theory of core capability, business organization, and competition space in the business world is emerging as the considerations towards enterprise transformation. As a tool, interpretive structural modelling is used for describing and analyzing the relationship between influence factors. Through literature review and expert opinions, nine factors are found.

2 Literature Review

2.1 Core Capability

For the study of enterprise transformation, scholars mainly start from the perspective of core capability [1].

Core rigidity is an excessively stable force caused by successful products, markets, technologies, talents and management based on core capability [2]. When the environment changes and organizations need to develop new core capabilities, the old knowledge and original capabilities will hinder the transformation of current core capabilities. Because core competence can bring lasting and stable competitive advantage, enterprises make full use of the existing resources and capabilities to create a set of advantages that are vague, valuable and difficult to imitate. However, with the changes of environment, the actions of competitors, and the emergence of new technologies, the core capability carefully nurtured and constructed by enterprises will become worthless overnight.

Core rigidity makes core capability itself rigid and difficult to expand, thus inhibiting the sustained innovation, and difficult to overcome by enterprises themselves. Core flexibility means that the core capability can interact with the internal and external environment of the enterprise, and then make continuous, timely and low-cost adjustments. The purpose of core flexibility is to establish sustainable competitive advantage of enterprises. Core flexibility can drive product or service adaptation to gain competitive advantage in a rapidly changing environment [3].

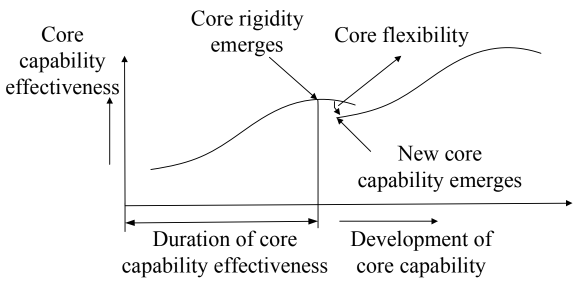

Fig. 1 Core rigidity, core flexibility, and core capability effectiveness with the development of core capability

Core capability effectiveness refers to its capability to create value, reflected in the economic performance generated by core capability, and the effectiveness of integrating internal and external resources [4]. As core capability is strengthened, core capability effectiveness will be enhanced, but the core capability has an upper limit. As core capability becomes rigid, the core capability effectiveness will no longer be enhanced, and the enterprise must develop new core capabilities.

Though core rigidity, core flexibility, and core capability effectiveness influence enterprise transformation in different ways, they are not isolated. Figure 1 shows them with the development of core capability.

With the development of core competence, core capability effectiveness is gradually improved. The marginal benefit of core capability effectiveness decreases, core rigidity emerges, and the development of core capability is hindered. If there is core flexibility, the enterprise will develop new core capability.

2.2 *Business Organization*

Business organization is an important topic in the research of enterprise transformation. Enterprises, especially traditional enterprises, are facing major organizational changes in the process of transformation [5].

Organization efficiency refers to the proportional relationship between the output of various activities and the human, material and financial factors consumed. Since there is the connection of many subject contracts in business organization, the organizational goal is actually the target system formed by a group of goals. As the environment changes, the organization will evolve itself and its goals will continue to evolve [6].

Organization adaptability refers to the extent to which an organization adapts to changes in the external environment. It reflects the number of elements adapted to the external environment and the speed of coping with the changes of elements. Organizational adaptability is a long-term indicator of the mutual evolution of companies and the environment [7].

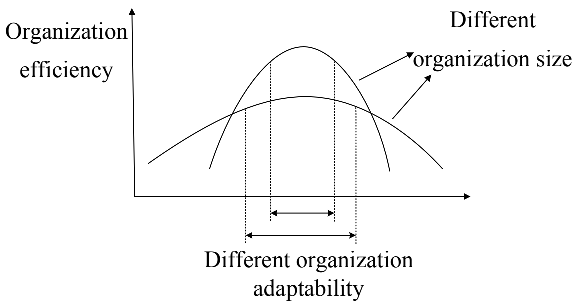

Fig. 2 Organization efficiency, organization adaptability, and organizational size

Organizational size is a reflection of the number of people and the interactions between these people. Organizational size influences organizational structure, and the scale suitable for technological innovation efficiency is dynamic [8].

Though organization efficiency, organization adaptability, and organizational size influence enterprise transformation in different ways, they are not isolated. Figure 2 shows them in the environment around enterprises.

It is assumed that the enterprise is only able to realize optimal organization efficiency within 5% of the resource width. The flatter the curve is, the larger the scope of its adaptation to the environment is. While the more round the curve is, the more efficient the organization is, but the smaller the scope of its maximum efficiency is.

2.3 Competition Space in the Business World

In the business world, enterprises are always in the competition space. In the process of enterprise transformation, information and energy are exchanged with the competition space all the time.

Strategy space is a collection of strategies that each player can choose. The strategic space mainly consists of three dimensions: customers, competitors, and the enterprise itself. Enterprise strategy is the basis of sustainable development in the existing diversified market environment, and also the extension premise to ensure the vitality [9].

Enterprises never create value in isolation, but form an ecosystem with stakeholders who have transaction relationships and business activities, and work closely together to achieve value delivery. The thinking space from the perspective of business ecosystem can be called business model space. The coincidence and change between economic space-time and physical space-time directly affect the motivation and process of business model innovation [10].

Each ecology follows the unique value creation logic to distribute resources, and to complete the closed loop from value creation to realization. The symbiont is the logic of value creation. Symbiont space is composed of the degree of freedom

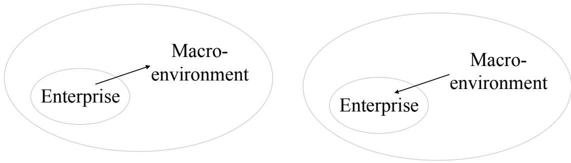

Fig. 3 Two ways of thinking

chosen by different communities of enterprises. Niche width affects the degree of niche separation and niche overlap, which leads to the change of competition intensity [11].

Though strategy space, business model space, and symbiont space influence enterprise transformation in different ways, they are not isolated. Different ways of thinking lead to different degrees of attention to the three spaces. Figure 3 shows two ways of thinking.

The former is a way of thinking from inside to outside, from part to whole. The enterprise first thinks about what problems it can solve, and finds the weak links that the competitors ignore. The enterprise explores what adjustments they need to make to adapt to the changes in strategy space, and pays little attention to business model space and symbiont space.

While the latter is a way of thinking from outside to inside, from whole to part. The enterprise first judges whether there is the possibility of the emergence or evolution of new symbiotic partners in symbiont space, then looks for the way to maximize value. Finally, the enterprise focus on the business model and strategy design.

Nine influence factors of enterprise transformation have been identified. Table 1 shows the list of influence factors.

Table 1 Influence factors

S. No.	Factor	Reference
1	Core rigidity	[2]
2	Core flexibility	[3]
3	Core capability effectiveness	[4]
4	Organization efficiency	[6]
5	Organization adaptability	[7]
6	Organization size	[8]
7	Strategy space	[9]
8	Business model space	[10]
9	Symbiont space	[11]

3 Methodology and Model Development

3.1 ISM Modeling

Interpretive Structural Modelling, as a tool, is built to analyze the complex relationship between variables. The methodology has been tested. It can draw the structure of the complex relationship. There are seven steps followed in ISM modeling: identification of the influence factors of enterprise transformation, design of interrelation between the factors, formation of SSIM, development of reachability matrix, division of reachability matrix, portray and description of mutual relation, examination for inconformity and subsequent amendment.

3.2 SSIM Matrix

A total of 38 questionnaires were distributed to industry experts through various channels such as WeChat, email, and questionnaire star. These experts were asked to judge the relationship between the nine influence factors based on experience. 34 valid questionnaires were collected. Table 2 shows the basic information of interviewees.

According to Table 2, most of the respondents are young practitioners with high educational background, most of them are in manufacturing and service industries, and there are more middle and senior managers. Respondents well represent the reality of employees in enterprise transformation. If no less than 80% of the respondents believe that the relationship between two factors exists, then we believe the relationship exist.

Table 2 Basic information of interviewees

Background	Option	Number	Proportion
Education	Junior college and above	6	17.6%
	Undergraduate	9	26.5%
	Master and above	19	55.9%
Working years	7 years or less	14	41.2%
	8–14 years	11	32.4%
	15 years or more	9	26.5%
Industry	Agriculture	6	17.6%
	Manufacturing industry	19	55.9%
	Service industry	9	26.5%
Position	Frontline workers/grassroots managers	9	26.5%
	Middle and senior managers	17	50.0%
	Professors/Associate Professor	8	23.5%

Table 3 Ssim matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1		O	V	O	O	A	X	A	O
F2			O	O	V	O	V	X	A
F3				V	O	A	A	A	O
F4					O	A	O	O	A
F5						A	O	A	O
F6							X	A	A
F7								A	A
F8									A
F9									

Contextual relationship is identified based on the experience of experts from the industry and academia. 4 symbols are applied to describe direction of action between variables (i and j):

$$a_{ij} = \begin{cases} V & i \to j \\ A & i \leftarrow j \\ X & i \leftrightarrow j \\ O & / \end{cases} \tag{1}$$

(a) V if i influences j (b) A if j influences i (c) X if i and j influence each other (d) O if i and j are at arm's length. Table 3 shows the SSIM matrix.

3.3 Reachability Matrix

With the help of the SSIM, the reachability is obtained. Number 1 or 0 replaces symbols V, A, X or O to create reachability matrix. The formula mode is followed:

$$b_{ij} = \begin{cases} 1 & a_{ij} = V \\ 0 & a_{ij} = A \\ 1 & a_{ij} = X \\ 0 & a_{ij} = O \end{cases} \tag{2}$$

$$b_{ji} = \begin{cases} 0 & a_{ij} = V \\ 1 & a_{ij} = A \\ 1 & a_{ij} = X \\ 0 & a_{ij} = O \end{cases} \tag{3}$$

Table 4 Reachability matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1	1	0	1	1	1	1	1	0	0
F2	1	1	1	1	1	1	1	1	0
F3	0	0	0	1	0	0	0	0	0
F4	0	0	0	0	0	0	0	0	0
F5	0	0	0	0	0	0	0	0	0
F6	1	0	1	1	1	1	1	0	0
F7	1	0	1	1	1	1	1	0	0
F8	1	1	1	1	1	1	1	1	0
F9	1	1	1	1	1	1	1	1	0

(a) If the (i, j) position in the SSIM matrix is V, the (i, j) position in the reachability matrix is 1, and the (j, i) position is 0 (b) If the (i, j) position in the SSIM matrix is A, then the (i, j) position in the reachability matrix is 0, and the (j, i) position is 1 (c) If the (i, j) position in the SSIM matrix is X, then the (i, j) position in the reachability matrix is 1, and the (j, i) position is 1 (d) If the (i, j) position in the SSIM matrix is O, then the (i, j) position in the reachability matrix is 0, and the (j, i) position is 0. Table 4 shows the reachability matrix created from SSIM.

3.4 Level Partitions

Antecedent set and reachability set are created for each influence factor by the use of the reachability matrix. The antecedent set include the factor which impact it and the factor itself, while the reachability set include the factors which influence it and the factor itself. The common factors between the reachability set and antecedent set are involved in the intersection set. If reachability set is the same with intersection set, the influence factor will be put on the top level. Table 5 shows level partition.

4 Result Analysis

4.1 ISM Based Model

Through level partition table and graphical representation, ISM based model is established. The relationship between different factors is represented by digraph. A digraph is drawn through level partition table. ISM based model can make the complex relationship between the influence factors and the level of variables more intuitive, and help to better understand business transformation. Figure 4 shows the ISM based model.

Table 5 Level partition table

Factor No.	Reachability set	Antecedent set	Intersection set	Level
F1	1,3,4,5,6,7	1,2,6,7,8,9	1,6,7	3
F2	1,2,3,4,5,6,7,8	2,8,9	2,8	4
F3	3,4	1,2,3,6,7,8,9	3	2
F4	4	1,2,4,6,7,8,9	4	1
F5	5	1,2,5,6,7,8,9	5	1
F6	1,3,4,5,6,7	1,2,6,7,8,9	1,6,7	3
F7	1,3,4,5,6,7	1,2,6,7,8,9	1,6,7	3
F8	1,2,3,4,5,6,7,8	2,8,9	2,8	4
F9	1,2,3,4,5,6,7,8,9	9	9	5

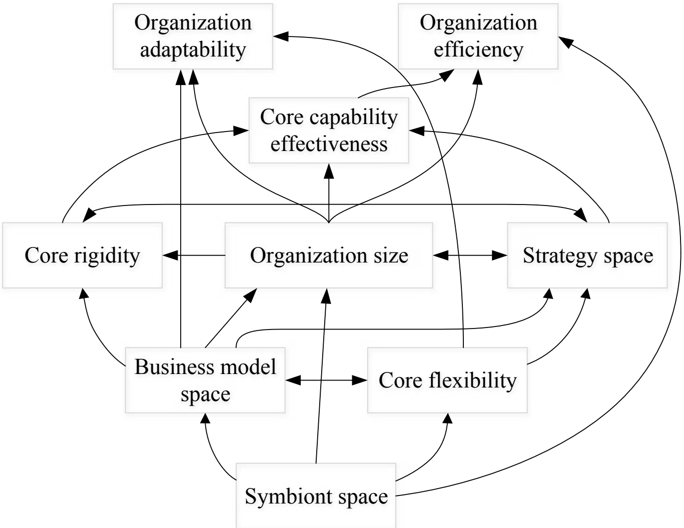

Fig. 4 ISM based model

4.2 Model Analysis

Seen from the ISM based model, the influence factors of enterprise transformation are divided into five levels. The influence factors of each level are different. The first and second levels are the surface direct factors, the third level is the middle dynamic factors, and the fourth and fifth levels are the deep guiding factors. The influence factors of the same level are intricate, and the influence factors of different levels may be interrelated and interact with each other.

(1) *Surface direct factors.* Organization adaptability, organization efficiency and core capability effectiveness are the surface direct factors of enterprise transformation.

Product, service, team, and technology have their own life cycle. Surface direct factors directly determine whether the enterprise follows the law of life cycle, thus directly affecting enterprise transformation. Organization adaptability reflects the sensitivity to market changes and helps the enterprise become aware of the stage of the life cycle. Organization efficiency reflects the speed of organization adjustments based on changes in the life cycle, ensuring that enterprises are able to update products and services in a timely manner. Core competency effectiveness reflects the quality of new products or services, including functionality, reliability, convenience, and cost.

Surface direct factors lead to short-term transformation results, which is significant for SMEs or enterprise grassroots, especially in the industry where products or services update rapidly. Therefore, SMEs or corporate grassroots should pay more attention to surface direct factors.

(2) *Middle dynamic factors.* Core rigidity, organization size, and strategy space are the middle dynamic factors of enterprise transformation.

Core rigidity and organization size determine the degree of immutability and diversification of products or services, and strategy space determines the direction and mode of enterprise transformation, thus directly affecting the surface direct factors. If the core rigidity is too strong and the core capability is inert, the core capability will stagnate, and the organizational efficiency will be reduced. Therefore, the transformation based on the original core is more suitable for the enterprise. The organization size adapted to enterprise transformation is dynamic. Breakthrough transformation are more suitable for loose enterprises in the network and small enterprises, while gradual transformation are more suitable for large enterprises. Strategy space reflects the understanding of the economic value of transformation direction and mode. Different understandings lead to different paths for enterprise transformation.

When enterprises are not hit by other industries, the direction and mode of transformation with the positioning, selection, focus and accessories of products or services will determine the success or failure of enterprise transformation. Therefore, enterprises should pay more attention to middle dynamic factors when ensuring that they are not hit by other industries.

(3) *Deep guiding factors.* Business model space, core flexibility and symbiont space are the deep guiding factors of enterprise transformation.

It is in the value network with different industries that the enterprise determines the needs of its customers, solve problems, solicits opinions, copes with competitors and maximizes profits. Deep guiding factors reflect the value network, changes of which affect the effectiveness of middle dynamic factors. Symbiont space contains all the supply chains and value chains of products and services, each of which can be separated, bent, and integrated. Business model space reflects that enterprises take measures to strive for profits. The competition of business model is the competition of profit pool. A better business model can enable enterprises to obtain a larger profit pool, then enterprises can depend on the profit pool to expand or reduce the organization size, change enterprise strategy, and develop core rigidity. Core flexibility is the ability of an enterprise to adjust to the dynamic, complex and unpredictable environment in the value network.

When enterprises are faced with shocks from other industries, companies will have a hard time defeating competitor if they only focus on surface direct factors and middle dynamic factors. Business model space, core flexibility and symbiont space will determine the success or failure of enterprise transformation. Therefore, when enterprises are faced with shocks from other industries, they should pay more attention to t deep guiding factors.

5 Conclusion and Recommendations

Nine factors are identified and analyzed which influence enterprise transformation. Factors are divided into the five levels through ISM modeling. Most studies focus only on one influence factor of enterprise transformation, lack the relationship between the factors, and ignore the applicability of influence factors. This paper clarifies the relationship between factors, divides the level of influence factors, and proposes the applicability of different levels of factors.

Analysis results display that enterprise leadership group must have clear overview of the market environment and the industry environment, understand different influence factors of the transformation, identify the main influence factors, and implement the environment adaptive strategies. When enterprises are faced with shocks from other industries, they should attach importance to deep guiding factors and avoid overemphasis on surface direct factors and middle dynamic factors. This paper will help the managers of enterprises in charting a blueprint for enterprise transformation. Enterprises should take the following measures specifically:

5.1 Ensure the Present

Surface direct factors determine the survival of enterprises in the short term. If an enterprise intends to have the future, it must first ensure the present. Therefore, entrepreneurs should not completely ignore the present and just focus on the future in the process of enterprise transformation.

Enterprises should strengthen organization adaptability, improve organization efficiency, and enhance core capability effectiveness. Following the life cycle law of products, services, teams and technologies, enterprises will provide appropriate products and services to meet market demand, and ensure short-term transformation successful.

5.2 Judge the Extent of Turbulence

By judging the extent of turbulence, enterprises can determine whether middle dynamic factors are the main influence factors of enterprise transformation.

In a static, simple and predictable environment, enterprises need core capability dominated by rigidity. In a dynamic, complex and unpredictable environment, core rigidity is an obstacle. To determine if there is core rigidity, enterprises need to judge the extent of environmental turbulence.

There is also turmoil within the organization. When the organization is at the edge of chaos, it is easier for enterprises to transform. Enterprises should judge the extent of organizational turbulence to ensure organization on the edge of chaos. Enterprises should control organization size to ensure that internal information flow, diversity, richness of connectivity, level of anxiety suppression, and right difference are reasonable.

Strategy space mainly consists of three dimensions: customers, competitors and the enterprise itself. Without hit from other industries, enterprises should answer three basic questions: for whom the enterprise creates value, who is the competitor, and what is the competitive advantage.

5.3 Pay More Attention to Deep Guiding Factors

In the process of enterprise transformation, the more dynamic, complex and unpredictable the environment, the greater the core flexibility required. Hit by other industries, enterprises should pay more attention to the core flexibility.

In addition, many managers only pay attention to the growth of operating income, and believe that profits will follow. However, in the process of enterprise transformation, the income pool is likely to become a dry pool. With the increase of the efficiency of social collaboration, the decline of the cost of external collaboration, and the blur of business boundaries, enterprises should take an insight into the true shape of the profit pool in business model space.

With top-level thinking from the perspective of symbiont space, entrepreneurs can have horizon and setup, know which space between enterprises to compete in ideas, and develop high-quality decision-making, planning, preparation and organization. Entrepreneurs should know all the supply chains and value chains of products and services, then separate, bend, and integrate them. The aim is to be in an invincible position in the process of enterprise transformation and initiative promotion of symbiotic evolution.

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