The Integration Degree of Logistics Industry and Regional Agglomeration Industry

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Abstract On the basis of the research on the coordinated development of regional economy, the degree of agglomeration of related industries is obtained through the calculation and analysis of location quotient, and the integration measurement model of agglomeration industry and logistics industry is constructed to analyze the development level and integration degree of logistics industry and related agglomeration industry. According to the types of integration and coordination degree between logistics industry and related agglomeration industry, the main reasons that restrict the integration and development are found out. On this basis, the linkage mechanism between agglomeration industry and logistics industry based on PDCA cycle is innovatively established. Finally, taking Hebei Province as an example, this paper studies the common problems in logistics industry, and puts forward corresponding countermeasures and suggestions.

Keywords Logistics industry · Industrial agglomeration · Coordinated development · Coupling model

1 Introduction

The phenomenon of industrial agglomeration occurs when a certain industry is highly concentrated in the region and the elements of industrial capital are constantly converged. Nowadays, with the deepening of the process of coordinated

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development of regional economy, industrial agglomeration has taken shape in many developed regions of the world and is gradually evolving into a unique economic state. Taking Hebei Province as an example, as a key area of coordinated development between Beijing, Tianjin and Hebei, while exploring its own industrial transformation and upgrading, it makes every effort to promote the construction of industrial undertaking platform, actively undertake the transfer projects between Beijing and Tianjin, and simultaneously upgrade the industry and expand the development space. After the exploration and preliminary practice in recent years, Hebei Province has achieved the stage results of industrial transformation and upgrading and industrial transfer undertaking, basically forming a new pattern based on industrial agglomeration mechanism.

In the process of industrial restructuring and industrial agglomeration, logistics industry plays an important role in supporting and linking. If the development of logistics industry cannot well support the adjustment of industrial structure and the formation of cluster industry in the region, it will limit the economic development of the whole region. Based on this, this paper proposes a measurement model for studying the integration and evolution of regional logistics industry and related agglomeration industry, and explores the bottleneck of regional logistics industry agglomeration. It also puts forward specific countermeasures for the development of logistics industry and ways to optimize logistics industry, and puts forward relevant suggestions for the future development of logistics industry.

2 Research Summary of Industrial Agglomeration and Logistics Collaborative Development

In recent years, scholars have begun to pay attention to the issue of industrial agglomeration and the coordinated development of regional logistics, and many new research perspectives and methods have emerged in related literatures. However, the theoretical relevance between literatures is still lacking, and the research system framework has not been fully formed.

Cui and Song attempted to build an econometric model from the perspective of endogenous growth and new economic geography, to investigate the impact of spillover effect of logistics agglomeration and scale economy on the development of China's logistics industry. The results show that the spillover effect of logistics agglomeration plays an important role in the development of logistics in different provinces [1]. Wang studied the relevant mechanism of industrial agglomeration and coordinated development of regional logistics integration and linkage, established the model of regional logistics and other industries' linkage development by using gray correlation analysis, and proposed the coordinated development strategy and safeguard measures of regional logistics at the micro level of enterprises and the macro level of economic space [2]. Jia et al. described the agglomeration situation of logistics industry in Henan Province. Through stepwise regression, it was found

that the spatial agglomeration degree of logistics industry was closely related to the upgrading of industrial structure. A systematic clustering was carried out for 15 cities in Henan Province, and the differences of agglomeration level of logistics industry in different cities were explained from the perspective of industrial structure [3]. Wang took automobile manufacturing industry cluster and regional logistics in Jiangxi Province as the research object, constructed the collaborative development evaluation model of automobile manufacturing industry and regional logistics through synergetic theory, and elaborated the cooperative evolution and development relationship between regional logistics and automobile manufacturing industry cluster in Jiangxi Province [4]. Guo and Qi constructed an evaluation index system for the coordinated development of regional logistics and regional economy. The coupling coordination between regional logistics and regional economic development in the Yangtze River Delta region between 2001 and 2016 was empirically analyzed by using the coupling degree mode [5]. Based on the analysis of the mechanism of the coupling and coordinated development of agriculture and logistics industry, Liang, Xu and Si constructed a coupling model to analyze the coupling and coordinated development of agriculture and logistics industry in the whole country and regions from 2004 to 2015 [6]. Hu established the coupling model between economy and logistics of urban agglomeration based on theoretical analysis and took the city group of Yangtze River Delta as an example to carry on the empirical research [7].

It can be seen from the above that relevant scholars have done a lot of research work on regional logistics and the development of regional industries. However, few literatures have systematically studied the integration degree of regional logistics and cluster industries. Therefore, how to improve the overall logistics industry to feed back the healthy development of relevant industry clusters has become an urgent problem for the logistics industry.

3 Establishment of Measurement Model for Integration of Logistics Industry and Related Agglomeration Industry

3.1 Calculation of Industrial Agglomeration Degree

In order to study industrial agglomeration in the region and make better use of logistics industry to promote the development of other agglomeration industries, this paper adopts Location Quotient (*LQ*) as the main method to study industrial agglomeration after referring to relevant literatures and researches of scholars. The specific calculation equation is as follows:

$$LQ = \cfrac{P_i \Big/ \sum_{i=1}^{n} P_i}{\sum_{j=1}^{m} P_{ij} \Big/ \sum_{i=1}^{n} \sum_{j=1}^{m} P_{ij}} \qquad (1)$$

In (1), P_i represents the output value of i industry in the region, $\sum_{i=1}^{n} P_i$ represents the total output value of all industries in the region, $\sum_{j=1}^{m} P_{ij}$ represents the output value of i industry in the country, and $\sum_{i=1}^{n} \sum_{j=1}^{m} P_{ij}$ represents the total output value of all industries in the country. If $LQ > 1$, it indicates that i industry has a higher degree of specialization and agglomeration in the region, and has certain development advantages. If $LQ < 1$, it indicates that the development of i industry in the region is at a disadvantage with a low degree of agglomeration, lower than the average level of the industry development. If $LQ = 1$, it means that the development of i industry in the region is in equilibrium.

3.2 Construction of Fusion Degree Model

Fusion refers to the integration of two or more different things, and the degree of fusion refers to the degree of correlation between different things. This paper studies the impact of integration elements between logistics industry and related agglomeration industry, constructs a measurement index system and evaluation criteria for quantitative calculation, and then provides decision-making basis for the integration of the two industries. This model is suitable for evaluating the integration degree of agriculture and tourism, manufacturing and service industries, urban development and economic environment, logistics and regional economy.

Hypothesis: $F(X^T)$ represents the development level of logistics industry in the region, and X represents the main development index of logistics industry in the region. $G(Y^T)$ is the development level of relevant industries in the region, Y is the main development index of relevant industries in the region, and T represents the time point, usually referring to month, quarter and year, etc.

Thus, the comprehensive evaluation model of the development level of logistics industry and agglomeration industries in the region at time T is established:

$$F(X^T) = \sum_{i}^{m} a_i x_i, \ \sum_{i}^{m} a_i = 1 \qquad (2)$$

$$G(Y^T) = \sum_{j}^{n} b_j y_j, \ \sum_{j}^{n} b_j = 1 \qquad (3)$$

In the equation, m represents the number of evaluation indexes related to the logistics industry in the region, a_i denotes the weight value of the logistics industry index i in the region, n represents the number of evaluation indexes involving the relevant industries in the region, and b_j represents the weight value of the relevant industrial indicator j in the region. The higher the calculated value of the evaluation function, the better the development of the system. x_i and y_j are normalized values in the range of (0, 1].

The quantitative model of integration degree of logistics industry and related industries in the region is established as follows:

$$D(T) = \sqrt{C(T) \times R(T)} \tag{4}$$

Among them:

$$C(T) = \sqrt{\frac{F(X^T)G(Y^T)}{[F(X^T) + G(Y^T)]^2}} \tag{5}$$

$$R(T) = \delta F(X^T) + \theta G(Y^T), \delta + \theta = 1 \tag{6}$$

In the equation, $R(T)$ represents the comprehensive evaluation level of logistics industry and related agglomeration industries, and reflects their comprehensive benefits and development. δ and θ are undetermined parameters, and the general value range is (0,1), which is usually 0.5. $D(T)$ indicates the degree of integration of logistics industry and related cluster industries. The higher the value is, the higher the degree of integration of logistics industry and related industries will be. Overall, the model has good stability and applicability.

3.3 Evaluation Criteria of Fusion Degree

Generally, the calculation results of $F(X^T)$ and $G(Y^T)$ can be divided into three situations: $F(X^T) > G(Y^T)$ indicates that the development speed of logistics industry in the region is faster than that of agglomeration industries, and the development speed of agglomeration industries is relatively slow. $F(X^T) < G(Y^T)$ indicates that the development speed of related agglomeration industries in the region is faster than that of logistics industry, and the development of logistics industry is slow. $F(X^T) = G(Y^T)$ indicates that the development speed of logistics industry in the region is synchronized with the development speed of related agglomeration industries. Specific evaluation criteria are shown in Table 1.

Table 1 Evaluation criteria of fusion degree grade

| Fusion degree	Fusion level	Fusion degree	Fusion level
[0, 0.1)	Extremely incompatible	[0.5, 0.6)	General fusion
[0.1, 0.2)	Highly incompatible	[0.6, 0.7)	Mild fusion
[0.2, 0.3)	Moderate incompatibility	[0.7, 0.8)	Moderate fusion
[0.3, 0.4)	Mild incompatibility	[0.8, 0.9)	Highly integrated
[0.4, 0.5)	Barely fusion	[0.9, 1.0)	Extreme fusion

4 Empirical Research

Taking Hebei Province as an example, this paper studies its industrial agglomeration under the background of the coordinated development of Beijing, Tianjin and Hebei. By calculating the degree of integration between logistics industry and agglomeration industry, it analyzes the coordinated development of logistics industry and related agglomeration industries in the new environment after undertaking the industrial transfer of Beijing, Tianjin and Hebei, so as to improve the development level of logistics industry, and at the same time rely on logistics industry to reverse the development level of related agglomeration industries, thus achieving the goal of mutual promotion and common development.

4.1 Analysis of Industrial Agglomeration

With reference to relevant data in China statistical yearbook, this paper selects eight industries including agriculture, forestry, animal husbandry and fishery, industry, transportation, warehousing and post office in Hebei Province from 2010 to 2016 for cluster analysis and research, and summarizes transportation, warehousing and post office as logistics industry. Equation (1) is used to calculate the location quotient of relevant industries in Hebei Province. Meanwhile, in order to better highlight the advantageous industries of Hebei province in Beijing-Tianjin-Hebei region, the overall index of Beijing-Tianjin-Hebei region is selected to replace the national index as the denominator for calculation [8]. The calculation results and variation trend of specific location quotient are shown in Fig. 1.

In 1 *a* represents agriculture, forestry, animal husbandry and fishery, *b* represents industry, *c* represents construction industry, *d* represents wholesale and retail trade, *e* represents logistics industry, *f* represents accommodation and catering, *g* represents financial industry and *h* represents realty industry. It can be seen that under the background of the coordinated development of Beijing-Tianjin-Hebei, the location quotient of these eight industries in Hebei Province increased year by year to a certain extent from 2010 to 2016, and showed an upward trend. Among them, agriculture, forestry, animal husbandry and fishery showed obvious agglomeration advantages.

Fig. 1 Development trend of location quotient of major industries in Hebei Province from 2010 to 2016
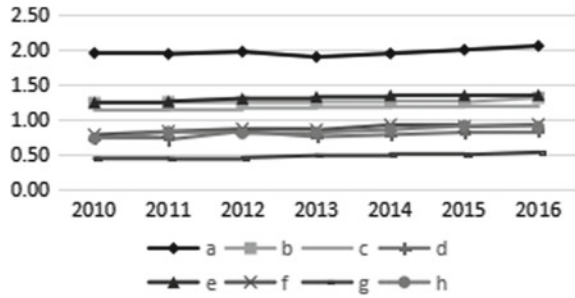
In 2016, its location quotient reached 2.15, and its development level has been significantly higher than the average level of Beijing-Tianjin-Hebei. In addition to agriculture, forestry, animal husbandry and fishery, the location quotient of industry, construction industry and logistics industry was also greater than 1. The location quotient of wholesale and retail, accommodation and catering industry, financial industry and real estate industry was all less than 1, which indicated that they did not show obvious agglomeration advantage in Hebei Province. From the above analysis, we can see that the agglomeration level of the primary industry and the secondary industry in Hebei Province was relatively high, while the tertiary industry did not show obvious agglomeration advantages except the logistics industry.

4.2 Index Selection and Weight Calculation

According to the principle of selecting indicators such as representativeness, systematicness, pertinence, operability and scientificity, this paper establishes the evaluation index system of the four agglomeration industries from three aspects of infrastructure, industrial scale and development capacity, on the basis of referring to relevant literature and the development status of Hebei industry, in order to achieve the degree of integration of logistics industry and related industries. In order to avoid the defects caused by subjective judgment, entropy weight method is selected in this paper to calculate and determine the weight of each index objectively, that is:

$$a_i = \frac{1 - E_i}{\sum (1 - E_i)}, \quad (i = 1, 2, \ldots, t) \tag{7}$$

$$b_j = \frac{1 - E_j}{\sum (1 - E_j)}, \quad (j = 1, 2, \ldots, t) \tag{8}$$

Equation $E_i = -\ln(t)^{-1} \sum_{i=1}^{} p_i \ln p_i$, $P_i = \frac{x_i}{\sum_{i=1}^{} x_i}$, If $p_i = 0$, define $\lim p_i \ln p_i = 0$.

Equation $E_j = -\ln(t)^{-1} \sum_{j=1}^{} p_j \ln p_j$, $P_j = \frac{y_j}{\sum_{i=1}^{} y_j}$, If $p_j = 0$, define $\lim p_j \ln p_j = 0$.

Referring to the data in National Statistical Yearbook and Hebei Economic Yearbook from 2011 to 2017, the specific index system and the weight of each index are shown in Tables 2, 3, 4 and 5.

Table 2 Logistics industry development level evaluation index and weight

Level indicators	Weight	Secondary indicators	Weight
Infrastructure	0.358	Per capita highway operating mileage	0.150
		Per capita railway operating mileage	0.125
		Cargo car ownership	0.083
Industrial scale	0.416	Number of people engaged	0.097
		Per capita freight volume	0.127
		Per capita postal and telecommunications business volume	0.192
Development ability	0.226	Industrial added value as a proportion of GDP	0.078
		Fixed asset investment	0.148

Table 3 Agriculture, forestry, animal husbandry and fishery development level evaluation index and weight

Level indicators	Weight	Secondary indicators	Weight
Infrastructure	0.363	Main machinery ownership	0.083
		Effective irrigation rate	0.096
		Cargo car ownership	0.184
Industrial scale	0.294	Number of people engaged	0.196
		Unit area yield of agricultural products	0.098
Development ability	0.343	Product Value Added as a Proportion of GDP	0.107
		Fixed asset investment	0.236

Table 4 Evaluation index and weight of industrial development level

Level indicators	Weight	Secondary indicators	Weight
Infrastructure	0.377	Total assets	0.177
		Contribution rate of total assets	0.200
Industrial scale	0.203	Total labor productivity	0.099
		Main business income	0.104
Development ability	0.420	Industrial added value	0.099
		Fixed asset investment	0.199
		Total profit	0.122

Table 5 Construction industry development level evaluation index and weight

Level indicators	Weight	Secondary indicators	Weight
Infrastructure	0.274	Technical equipment rate	0.112
		Power equipment rate	0.162
Industrial scale	0.234	Number of people engaged	0.126
		Floor space of buildings completed	0.108
Development ability	0.492	Industrial added value as a proportion of GDP	0.183
		Fixed asset investment	0.202
		Total profit	0.107

4.3 Computation and Analysis of Fusion Degree

Based on the above evaluation index system and the coupling degree synergy model, the following calculation and analysis are made on the integration degree of logistics industry and related agglomeration industry in Hebei Province from 2010 to 2016.

As can be seen from Table 6, the integration level of logistics industry and agriculture, forestry, animal husbandry and fishery, industry as well as construction industry in Hebei Province has been increasing year by year from 2010 to 2016, with an overall upward trend. Among them, the average degree of integration between logistics industry and agriculture, forestry, animal husbandry and fishery are 0.492, and the highest degree of integration is 0.590 in 2016. The development of integration between logistics industry and agriculture, forestry, animal husbandry

Table 6 The integration degree of logistics industry and related industries in 2010–2016

Industrial integration degree	Logistics industry and agriculture, forestry, animal husbandry and fishery		Logistics industry and industry		Logistics industry and construction industry	
	Fusion degree	Fusion level	Fusion degree	Fusion level	Fusion degree	Fusion level
2010	0.418	Barely fusion	0.336	Mild incompatibility	0.391	Mild incompatibility
2011	0.372	Mild incompatibility	0.375	Mild incompatibility	0.385	Mild incompatibility
2012	0.430	Barely fusion	0.467	Barely fusion	0.513	General fusion
2013	0.524	General fusion	0.564	General fusion	0.557	General fusion
2014	0.538	General Fusion	0.565	General fusion	0.568	General fusion
2015	0.570	General fusion	0.562	General fusion	0.569	General fusion
2016	0.590	General fusion	0.616	Mild fusion	0.557	General fusion

and fishery has gone through a stage from barely fusion, mild incompatibility to general fusion. Although the degree of integration between industries is gradually improving, the integration level is still at a medium level. The integration of logistics industry and industry is the best among the three. It has experienced four stages of development: mild incompatibility, barely fusion, general fusion and mild fusion. In 2016, it reached the highest integration level of 0.616, and entered a new stage of mild integration. Logistics and construction industry from the initial mild incompatibility to the general fusion stage, and the degree of integration is 0.557 in 2016. It can be seen that the fusion degree of the three is stable between 0.500 and 0.700. Although the fusion degree is constantly improving, it still does not reach a very ideal fusion state. In order to improve the overall level of coordinated development in Beijing, Tianjin and Hebei, it is necessary to further strengthen the integration of the three.

According to the model above, we can get the types of integration and coordination degree of logistics industry and related agglomeration industry, and make the following analysis for the reasons of imbalance of coordination between logistics industry and related industries.

From Table 7, we can see that the logistics industry in Hebei Province has developed slowly in the past few years, and has not kept pace with the development of agriculture, forestry, animal husbandry and fishery, industry and construction industry, which was at a disadvantage in the process of industrial integration. However, since 2013, due to the sudden outbreak of online shopping market, the construction of e-commerce logistics network system has been promoted. The development of China's logistics industry has attracted the comprehensive attention of the central and local governments. Hebei Province has also increased its attention to the logistics industry, resulting in the continuous improvement of the level of development of the logistics industry, and the development speed has exceeded the development speed of related agglomeration industries. In the following years, the logistics industry has maintained its development advantages, and in the process of integration with other industries, the development speed has been in the lead. At present, the degree of integration between logistics industry and other industries is not high, which is largely due to the fact that logistics industry and other agglomeration industries have not yet formed a cooperative development mechanism. Although the development speed of logistics industry is constantly improving, its development level still has no obvious advantages compared with other agglomeration industries. Therefore, in order to improve the degree of integration between logistics industry and related agglomeration industry, we need not only related agglomeration industry to promote the development of logistics industry, but also the logistics industry to rely on its own development advantages to promote the continuous progress of other industries, so as to achieve mutual coordination and linkage development and jointly improve the development level.

Table 7 Types of integration and coordination degree between logistics industry and related industries in 2010–2016

Fusion coordination type	Industry		
	Logistics industry and agriculture, forestry, animal husbandry and fisheries	Logistics industry and industry	Logistics industry and construction industry
2010	Logistics industry develops slowly	Logistics industry develops slowly	Logistics industry develops slowly
2011	Logistics industry develops slowly	Logistics industry develops slowly	Logistics industry develops slowly
2012	Logistics industry develops slowly	Logistics industry develops slowly	Logistics industry develops slowly
2013	Agriculture, forestry, animal husbandry and fishery develops slowly	Industry develops slowly	Construction industry develops slowly
2014	Agriculture, forestry, animal husbandry and fishery develops slowly	Logistics industry develops slowly	Logistics industry develops slowly
2015	Agriculture, forestry, animal husbandry and fishery develops slowly	Industry develops slowly	Construction industry develops slowly
2016	Agriculture, forestry, animal husbandry and fishery develops slowly	Industry develops slowly	Construction industry develops slowly

4.4 Establishing Linkage Mechanism between Logistics Industry and Agglomeration Industry

In order to meet the new demands of the cluster industry on the logistics industry in Hebei Province, the logistics industry and other cluster industries can be developed in a coordinated way, so as to promote each other and make common progress. Therefore, this paper establishes the linkage mechanism of industrial agglomeration and logistics industry agglomeration based on PDCA cycle to coordinate the relationship between logistics industry and related industries. The linkage mechanism model is shown in Fig. 2.

PDCA cycle linkage mechanism is to divide the process of logistics industry agglomeration and related industry agglomeration into four stages, namely *plan*, *do*, *check* and *adjust*, and keep on circulation according to this step. First of all, in the *plan* stage, relevant government departments are required to formulate reasonable industrial development planning, and implement industrial collaborative planning according to the requirements. Secondly, in the *do* stage, the development of logistics industry agglomeration and other industrial agglomeration complement
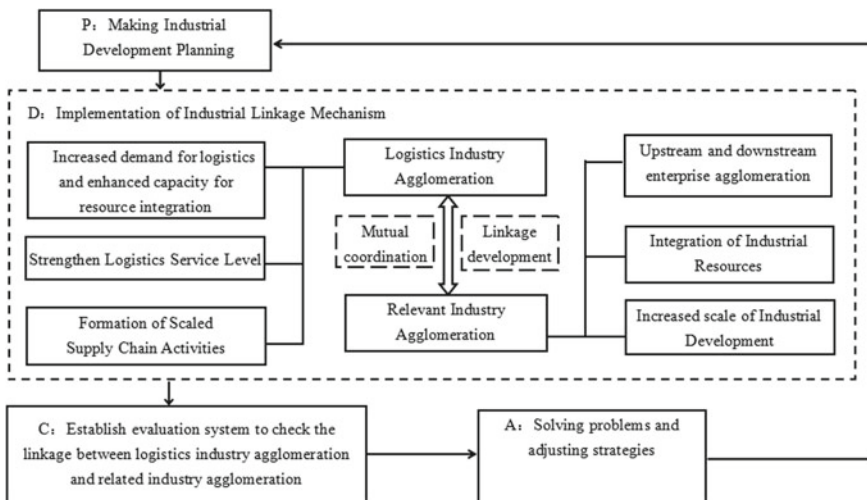
Fig. 2 Linkage mechanism of industrial agglomeration and logistics industry agglomeration based on PDCA cycle

each other. On the one hand, related industrial agglomeration can promote the development of logistics industry agglomeration. On the other hand, the agglomeration of logistics industry can also drive the development of other industry agglomeration. For the *check* stage, it is necessary for the relevant government departments to formulate a reasonable evaluation system, regularly evaluate and analyze the current situation of logistics industry agglomeration and related industry agglomeration. Finally, in the *adjust* stage, according to the inspection results of the previous stage, we formulate adjustment strategies, solve the problems in the previous plan and implementation, and lay a good foundation for the next round of plan.

The linkage mechanism of industrial agglomeration and logistics industry agglomeration can meet the new demands of the agglomeration industry for logistics industry. At the same time, it not only provides a solution for the coordinated development of logistics industry and agglomeration industry, but also lays a foundation for their integration and development.

5   Conclusions and Recommendations

Based on the background of coordinated development of regional economy, this paper studies the integration of logistics industry and related agglomeration industry in this environment. Firstly, through the calculation and analysis of location quotient, the agglomeration degree of related industries is obtained. At the same time,

in order to better grasp the degree of integration of logistics industry and agglomeration industry, so as to promote the future development of regional economy, this paper constructs a coupling degree coordination model, and on this basis, establishes an industrial agglomeration and logistics industry agglomeration mechanism based on PDCA cycle, hoping that this mechanism can provide a reference for the integration and development of logistics industry and related agglomeration industry. Taking Hebei Province as an example, this paper conducts an empirical study and finds that except for the logistics industry, agriculture, forestry, animal husbandry and fishery, industry and construction industry in Hebei Province have formed industrial agglomeration at the same time. This paper establishes the coupling degree collaborative model, and analyzes the data of Hebei Province from 2010 to 2016. Finally, it is found that the degree of integration of logistics industry and related industries in Hebei Province is constantly improving. However, the degree of industrial integration is still unsatisfactory.

In order to improve the integration of the logistics industry with other industries, and further improve the overall development level of the industry in Hebei Province, this paper proposes the following suggestions after synthesizing the above research results: (1) Break the industrial boundaries and form a situation of industrial convergence and development. After fully understanding the characteristics of each industry, the relevant departments in Beijing, Tianjin and Hebei should formulate development policies suitable for each industry, break the boundaries between different industries, avoid the isolated development of industries, take advantage of the advantages of integration and development among industries, and promote the coordination and common development of each industrial cluster. (2) Improve the degree of specialization of logistics industry and create advantages of industrial cluster. Because each region has its own characteristics, it will form corresponding specialized demand. Although many related industries in Beijing, Tianjin and Hebei have formed industrial agglomeration, their degree of specialization is not enough. Therefore, each agglomeration industry should widely tap the current demand situation in the region and improve its level of specialization. (3) Improve the level of logistics services and give full play to the mutual promotion between industries. In the process of coordinated development of Beijing, Tianjin and Hebei, logistics industry has been paid more and more attention, and its development speed is relatively fast, but the level of development still needs to be further improved. As the pillar of the service industry, while meeting the service needs of other industries, the logistics industry should take the initiative to attack the market and constantly cultivate its own new advantages to guide and support the development of other industries. Use services and potential services to leverage demand and potential demand, and form a continuous iteration of demand and service, so as to realize the coordinated development of Beijing, Tianjin and Hebei based on industrial integration mechanism.

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