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Development Potential of Chinese Construction Industry in the New Century based on Regional Difference and Spatial Convergence Analysis

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Abstract

The development of Chinese construction industry is strongly influenced by geographic locations. And it shows an obvious ladder-like distribution showing a decreasing trend from the east to the middle and the west. The persistent occurrence and excessive expansion of such differences not only affects the overall efficiency of the construction industry's development, but also reflects an inefficient allocation of resources. Based on this, we attempt to combine multiple attribute model with time series and convergence models, make the regional difference and spatial convergence analysis of the development potential of Chinese construction industry and describe the differences of the development potential for the construction industry existing in the three examined regions of China. So decision makers can be provided with an accurate and reliable basis. The research indicates that in the new century, all the regions in China show an enormous potential for the growth of a highly developed construction industry. The west has the greatest development potential, with the middle following behind closely; Compared with this, the east is the weakest. It also finds that there is an absolute convergence in the development potential of the Chinese construction industry. Furthermore, it formulates the club convergence for the east, the middle and the west. The effective combination of multiple attribute model with time series, absolute convergence and club convergence models can avoid the shortcoming of the subjective weighting method and realize the innovation of the research methods for the development potential of construction industry.

Keywords: *construction industry, development potential, difference, convergence*

1. Introduction

Since the beginning of the new century, the construction industry has been the fourth pillar of Chinese industry after industry, agriculture and commerce. In 2009, the total output value of the construction industry was 7,586.4 billion RMB, up 22.3% from 2008; the profit rose to 266.3 billion RMB, increasing by 21.0% over 2008 (National Bureau of Statistics of China, 2009). In essence, the construction industry has a close, complex, and comprehensive relationship with the other industries at the macroeconomic level. Also, the construction industry has a positive correlation with the development cycle of the national economy; that is, the scale of the construction industry depends largely on the demand of the national economy on fixed assets, especially in regards to infrastructure, real estate, and the urbanizing evolution (Fan, 2009).

The construction industry is a typical policy oriented industry, which is directly affected by national development strategies, macroeconomic regulation, and the structural adjustment of industries. With such a vast territory, China's regional economic development is imbalanced, and so is the development of regional construction industries. This imbalance leads to an obvious ladder-like distribution of the construction industry's development, with a decreasing trend from the east to the middle and the west (Liu *et al*., 2011). The persistent occurrence and excessive expansion of such differences not only affects the overall efficiency of the construction industry's development, but also reflects an inefficient allocation of resources. Therefore, it is a major concern for both academia and the government to diminish the gaps between the regions, make the industrial development policies scientifically and optimize the resource allocation of the construction industry. Unfortunately, at present the academia hasn't attached importance to the construction industrial economy (Chau and Walker, 1988). And correspondingly, there has been virtually no research in this field. The current researches mainly focus on industrial competitiveness, industrial efficiency and industrial organization, except industrial development potential.

Based on this, this paper intends to construct an indicator system for the development potential of the Chinese regional construction industry, with the reference to the development potential indicators

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of other industries. We combine multiple attribute model with time series, absolute convergence model, and club convergence model, so as to avoid subjective weighting and describe the gradual progress of the development potential of China's construction industry as well as the differences among the regions. Thus, the combination of several convergence models can realize the innovation on the research of industrial development potential.

2. Literature Review

There is a close relationship between industrial competitiveness and industrial development potential: the former reflects the current development level of an industry, and the latter represents both the developing and future follow-up abilities of an industry (Wang *et al*., 2008). To some extent, industrial development potential is an unrealistic capability which is a key element for the competitiveness in future. Therefore, under the situation that there is lack of the mature indicator system for development potential of the construction industry, we intend to review the relevant literatures on industrial development potential and construction industrial competitiveness, and combine the analytical framework for industrial development potential and the features of the construction industry, in order to construct the indicator system of the development potential of construction industry.

2.1 Review Within Industrial Development Potential

At present, the researches of industrial development potential mainly focus on the industries including tourism, high and new technology, real estate, and so on. Few research results have been holistic in scope. Besides, almost no relevant literature on the construction industry has been found.

Koschatzky *et al.* (2001) analyzed structural characteristics of the Slovenian manufacturing industry and its development and innovation potential with the data from an industrial innovation survey. Chang *et al.* (2002) presented a detailed study on the future development of Taiwan's machinery industry along with the valuable proposals to the government policy and the investment strategy to the private sectors, with the methods including SWOT analysis and the Delphi method. Chen *et al.* (2006) applied DEA to analyze the comparative performances of the six high-tech industries currently developed at Taiwan's Hsinchu Science park, and used malmquist indices of productivity change to analyze the development potentials of the six high-tech industries. Shi and Chen (2006), with the Cobb-Douglass production function, chose the capital input and labor input indicators and conducted an empirical investigation of the development potential for the construction industry in Heilongjiang Province. Wang (2008) constructed an indicator system for the regional tourist industry, which includes resource potential, marketing potential, developing benefit, social and economic supportive conditions, and developing supportive conditions. Yu (2009) proposed that the development potential of tourism industry was formed gradually under the condition where the resources were affected by various internal and external environmental factors. And the potential ability could support and protect the competitiveness and development of the industry in future. Based on the theory, the indicator system of development potential of tourism industry was constructed, which included growing potential, marketing expanding potential, and sustainable developing potential. Liu Guiwen *et al.* (2010) constructed the index system of development potential of real estate market consisting of growing potential, effectiveness potential and stability potential. And they applied multiple index comprehensive evaluation with time series to evaluate the real estate industries of 31 cities in China.

We can learn from the above that a complex and comprehensive analytical framework for industrial development potential hasn't been established. Moreover, the main research achievements are based on static analysis, instead of taking dynamic persistence into account and making analysis of interval convergence. Accordingly, academia generally focuses on indicators suitable to effectiveness, market expansion, resource potential, and operational profit.

2.2 Review Within Construction Industrial Competitiveness

The domestic and foreign researches on the construction industrial competitiveness have concentrated on the firm level, but there are few for the industrial level (Liu *et al*., 2010). The scholars such as Oz (2001), Dunning (1992), Grant (1991), Ofori (1994; 2003), Momaya and Sellby (1998), Ive (2004), Seymour (1979), Rashid (1990), Mawhinney (2001), Arditi et al. (1997), Zhi *et al*. (2003), Griliche (1980), Dacy (1965), Stocks (1981), Allen (1985), Denison (1972), Wang and Li (2008), Wang and Ye (2008), Yao and Jin (2007), Chen and Wang (2007), Gong and Cheng (2000), Zhou (2006), Kang and Meng (2008), and Liu *et al.* (2011) respectively made the theory and empirical researches on the construction industrial competitiveness from different perspectives. After combing the above literature, construction industrial competitiveness can be summarized by eight major indicators: operational profit, production factor, role of the government, auxiliary industry, demand condition, industrial organization structure, productivity, and innovation factor.

2.3 Construction of the Indicator System of Development Potential of the Construction Industry

The construction industry is regarded as industry, so it should have the general industrial characteristics. In general, industry development potential includes four indicators: operational profit potential, market expansion potential, resource potential and effectiveness potential. For operational profit potential of the construction industry, we choose total profit and total income. For market expansion potential of the construction industry, it can be reflected by the amount of products and services from the construction industry, as well as the demand for the productions. We choose total output value to represent the former and housing construction area to represent the latter. For resource potential or input potential of production factors of the construction industry, we mainly use liabilities plus the owner's total equities, the number of employees and the total power of the owned construction equipment at the end of the year to reflect assets, human and material resources in construction industry respectively. And labor productivities based on total output value and added output value are chosen to reflect the improvement of industrial productivity.

Besides, the construction industry also has its own characteristics. Firstly, as this industry depends primarily on the demands of the national economy's development of fixed assets. The higher the demand, the greater the scale of industry; and the faster the demand increases, the faster the industry develops. Moreover, the output values of associated industries, especially real estate and industry, have indirect impacts on the demand in the construction industry. So we choose fixed asset investment, output values of the real estate industry and the whole industry to represent improvement of the demand conditions of the construction industry. Secondly, compared with other industries which supply products, the construction industry supplies the capability of production and service, and has the features such as a long production cycle, strong liquidity, and complicated organization. In its production process, several ancillary industries are needed, such as engineering design, supervision, survey and design, and cost consulting. Hence, the development levels of these ancillary industries have an impact on the competitiveness of the construction industry. We choose the number of survey and design institutions and the number of survey and design practitioners to reflect the development levels of ancillary industries.

And then, this paper does the research into the development potential of the construction industry from six aspects --- that is, demand condition, market expansion, operational profit, factor of production, development of the ancillary industries, and improvement of productivity. Meanwhile, Based on the principle of comprehensiveness and feasibility, considering the data availability of China's construction industry, we propose constructing an indicator system for the development potential of China's construction industry, composed of six categories and 14 indicators (see Table 1). It should be noted that as the development potential reflects the dynamic transformation in the process of industry development, the above indicators are replaced with its ratio indicators.

3. Methodology

3.1 Multiple Attribute Model with Time Series

At present, the evaluation method of multi-index system is mainly composed of static evaluation and dynamic evaluation. As static evaluation cannot reflect how the indictors change in a period of time, we adopt a dynamic evaluation method, namely multiple attribute model with time series.

Assume the time set of multiple attribute with series as $T_k(k=1,2,\ldots,l)$, the scheme set as $A\{A_1,A_2,\ldots,A_n\}$, and the indicator set as $G=\{G_1,G_2,\ldots G_m\}$. In the year T_k, the attribute value of indictor G_j in scheme A_i is Y_{ij} ($i=1,2,3,\ldots,m; j=1,2,3,\ldots n; k=1,2,\ldots,l$). Where $Y^k=(y_{ij}^k)_n$ represents the attribute matrix of the scheme set A in the indicator set G. In general speaking, multiple attribute model with time series contains three steps.

Firstly, nondimensionalize the indicators.

(a) for the positive indicators, let $Z_{ij}^k=\dfrac{y_{ij}^k-y_j^{\min}}{y_j^{\max}-y_j^{\min}}$;

(b) for the negative indicators, let $Z_{ij}^k=\dfrac{y_{ij}^k-y_j^{\min}}{y_j^{\max}-y_j^{\min}}$;

(c) for the moderate indicators, let

$$Z_{ij}^k=\begin{cases}1-\dfrac{L_{1j}-y_{ij}}{\max(L_{1j}-y_j^{\min},y_j^{\max}-L_{2j})}, & y_{ij}<L_{1j}\\ 1, L_{1j}<y_{ij}<L_{2j} & \\ 1-\dfrac{y_{ij}-L_{2j}}{\max(L_{1j}-y_j^{\min},y_j^{\max}-L_{2j})}, & y_{ij}>L_{1j}\end{cases}$$

Where, $[L_{1j},L_{2j}]$ is the interval range of the moderate indicators.

Then the nondimensionalized matrix can be denoted as $Z^k=(z_{ij}^k)_{m\times n}(k=1,2,\ldots,l)$.

Secondly, obtain the weighted average value $D_i^k(\omega)$ of the scheme A_i in the year T_k.

Table 1. Indicator System of Development Potential of the Construction Industry

	Category	Indicator
Development potential of the construction industry	Improvement of the demand conditions	Fixed asset investment (x_1)
		Output value of the real estate industry (x_2)
		Output value of the whole industry (x_3)
	Operational profit	Total profit (x_4)
		Total income of the all construction enterprises (x_5)
	Market expansion	Total output value of the construction industry (x_6)
		Housing construction area of the construction industry (x_7)
	Input of factors of production	Liabilities plus the owner's equities (x_8)
		Number of employees (x_9)
		Total power of the owned construction equipment at the end of the year (x_{10})
	Development of ancillary industries	Number of survey and design institutions (x_{11})
		Number of survey and design practitioners (x_{12})
	Improvement of industrial productivity	Labor productivity based on total output value (x_{13})
		Labor productivity based on added output value (x_{14})

Assume that the weight vector of each indicator $\omega = (\omega_1, \omega_2, \cdots \omega_n)^T > 0$, and $\omega^T\omega = 1$. Therefore, the comprehensive estimation value of the scheme A_i in the year T_k is $G_i^k(\omega) = \sum_{j=1}^{n} Z_{ij}^k \omega_j$, namely $G_i^k(\omega) = Z^k\omega, k = 1, 2, \ldots, l$, and $G^k(\omega) = \{G_1^k(\omega), G_2^k(\omega), \cdots, G_m^k(\omega)\}$.

We introduce the weight vector $\alpha = (\alpha^1, \alpha^2, \ldots, \alpha^l)^T > 0$ to the time sequential vector $T = \{T_1, T_2, \ldots T_l\}$, which satisfies the condition that $\alpha^T\alpha = 1$. Thus, the comprehensive estimation value of the scheme A_i during the years T is $G^k(\omega) = \sum_{k=1}^{l} \alpha^k G^k(\omega)$.

Obviously, the bigger the value of $G_i(\omega)$ is, the better the situation is. Thus, construct the single-objective optimization model as Eq. (1).

$$\begin{cases} \max F(\omega) = \sum_{i=1}^{m} G_i(\omega) = \sum_{i=1}^{m}\sum_{k=1}^{l} \alpha^k G_i(\omega) \\ s.t \sum_{k=1}^{l} [\alpha^k]^2 = 1 \end{cases} \tag{1}$$

And the Eq. (2) can be obtained as follows:

$$\alpha^k = \sum_{i=1}^{m} G_i^k \Big/ \sqrt{\sum_{k=1}^{l}\left[\sum_{i=1}^{m} G_i^k(\omega)\right]^2}, k = 1, 2, \ldots l \tag{2}$$

As long as the comprehensive estimation value $G_i(\omega)$ $(k = 1, 2, \ldots, l)$ is known, the dynamic development estimation value $G_i(\omega)$ can be calculated.

Thirdly, obtain the weight vector among indicators.

In the long term, as the importance degree of each indicator changes, the weight vector will change correspondingly. Meanwhile, we can construct L single-objective sub-programming models.

$$\begin{cases} \max G(\omega) = \sum_{i=1}^{m} D_i^k(\omega) = \sum_{i=1}^{m}\sum_{j=1}^{n} Z_{ij}^k \omega_j \\ s.t \omega^T\omega = 1 \end{cases} \tag{3}$$

And as to the L different periods, we can get L different weight vectors ω^*.

$$\omega_j^* = \sum_{i=1}^{m} Z_{ij}^k(\omega) \Big/ \sqrt{\sum_{j=1}^{n}\left[\sum_{i=1}^{m} G_{ij}^k(\omega)\right]^2}, j = 1, 2, \ldots, n \tag{4}$$

Table 2. Development Potential of Chinese Regional Construction Industry

Region	General	2001	2002	2003	2004	2006	2007	2008	2009
Beijing	3.9064	1.2601	1.5918	0.9822	1.2530	2.5424	0.9004	1.0225	0.8514
Tianjin	3.9910	0.8612	0.8837	1.7625	1.2952	2.2669	1.6221	1.2987	1.1267
Hebei	4.6243	1.2248	1.7795	0.8309	1.0250	3.1448	0.5566	1.3984	2.0216
Shanxi	4.1940	0.7734	1.2813	1.9144	1.2777	2.4679	1.0306	1.2103	1.4874
Inner Mongolia	3.9099	0.7896	1.0043	1.2393	0.8590	2.5936	1.2605	1.6372	1.0379
Liaoning	3.7843	1.2566	1.4717	0.2900	0.8519	2.5850	1.0236	1.1512	1.2491
Jilin	3.9116	1.9842	1.4465	0.6407	0.9313	1.9752	1.0950	1.0046	1.9075
Heilongjiang	4.2489	1.3256	1.8866	0.7824	1.0995	1.9618	1.5491	1.6399	1.7381
Shanghai	3.8502	0.7781	0.7780	0.9540	1.8734	2.6881	1.0895	0.4506	1.4842
Jiangsu	3.6120	0.5393	0.5962	0.5078	0.9955	3.2620	0.8702	1.0710	0.8981
Zhejiang	4.3237	0.9806	1.6232	1.0423	1.8103	3.1007	0.8747	0.8360	0.9181
Anhui	4.0799	0.5078	2.2052	1.2158	0.7762	2.3872	1.2568	1.3424	1.2302
Fujian	4.4456	0.5142	1.7886	0.9966	1.7413	2.5553	1.6156	1.5637	1.2436
Jiangxi	4.4263	1.0075	1.9301	1.6283	1.8559	2.6460	0.7158	0.6848	1.4462
Shandong	3.6746	0.7108	1.0028	1.0239	1.5500	2.8032	0.6442	0.8615	0.7931
Henan	4.2725	0.5333	1.1011	0.7054	0.8537	3.1087	1.5968	1.7282	1.3724
Hubei	4.3181	0.8501	0.9522	0.8454	1.7349	2.7500	1.3332	1.8886	1.2045
Hunan	4.3275	1.1257	1.5870	1.0924	1.9534	2.5513	1.0591	1.0895	1.2736
Guangdong	3.8675	0.3426	1.6866	1.1004	0.8877	2.8305	0.9508	1.2169	0.8421
Guangxi	4.3831	0.9638	1.2273	1.3497	1.3617	2.6698	1.3778	1.6832	1.2546
Hainan	3.8407	1.1896	1.3880	1.0629	0.8382	2.2133	0.8217	1.0686	1.8526
Chongqing	4.1498	0.6451	2.3720	0.7404	0.9889	2.3164	1.0157	1.3477	1.6666
Sichuan	4.0268	0.7389	2.1475	1.9495	1.3062	1.4936	1.3724	1.4494	1.2689
Guizhou	3.4082	1.5129	1.8291	1.2994	0.6802	1.7825	0.5757	0.4447	1.3515
Yunnan	4.0247	0.8301	1.0893	0.2525	0.8860	3.0282	1.7460	1.0417	1.4137
Tibet	3.3602	1.2208	0.7303	1.5237	1.8090	1.4315	1.2165	1.2357	0.7279
Shanxi	4.3445	0.7438	1.3625	0.9318	1.1340	2.2981	1.1929	2.1930	2.0524
Gansu	3.4612	1.0612	0.7161	1.4811	1.1020	2.0542	0.6805	1.2761	1.1524
Qinghai	4.6910	1.3886	1.9937	2.1218	1.2158	1.9345	1.5861	1.7413	1.6312
Ningxia	3.9255	1.6473	1.7454	0.8063	1.7982	1.5856	1.0074	1.1800	1.5574
Xinjiang	3.5845	2.6739	1.1218	0.7129	0.8433	1.3986	0.9606	1.2578	1.6702

Table 3. Mean and Standard Deviation of the Development Trend of Chinese Regional Construction Industry

Region	Indictor	2001	2002	2003	2004	2006	2007	2008	2009
The nation	Mean value	1.0317	1.4297	1.0899	1.2448	2.4009	1.1161	1.2586	1.3460
	Standard deviation	0.4785	0.4776	0.4613	0.3967	0.5197	0.3318	0.3928	0.3602
The east	Mean value	0.8780	1.3264	0.9594	1.2838	2.7266	0.9972	1.0854	1.2073
	Standard deviation	0.3300	0.4321	0.3684	0.3998	0.3432	0.3427	0.3023	0.4215
The middle	Mean value	1.0134	1.5488	1.1031	1.3103	2.4810	1.2045	1.3235	1.4575
	Standard deviation	0.4815	0.4359	0.4611	0.4742	0.3841	0.2913	0.4072	0.2504
The west	Mean value	1.1847	1.4449	1.2007	1.1654	2.0489	1.1660	1.3740	1.3987
	Standard deviation	0.5731	0.5570	0.5396	0.3596	0.5382	0.3420	0.4297	0.3481

Based on the values of ω^*, the comprehensive estimation values of all schemes of each year can be calculated ultimately.

3.2 Acquisition of Data

Collect the data for the indicator system in Table 1 from *China Statistical Yearbook (2002-2010)*. Note that due to the lack of data in the yearbook 2005, we can't make research on the development potential of the construction industry in 2004.

3.3 Statistical Analysis

Based on multiple attribute model with time series, this paper made a statistical analysis for the 14 indicators from 31 provinces in China from 2001 to 2009.

Firstly, calculate the weight vector ω_j^* of the indicators.

$$\omega^{2001} = \{0.084, 0.437, 0.096, 0.299, 0.107, 0.107, 0.203, 0.206, 0.160, 0.241, 0.332, 0.463, 0.195, 0.388\}$$
$$\omega^{2002} = \{0.125, 0.215, 0.011, 0.303, 0.300, 0.246, 0.314, 0.307, 0.307, 0.335, 0.248, 0.317, 0.210, 0.300\}$$
$$\omega^{2003} = \{0.142, 0.202, 0.062, 0.267, 0.305, 0.268, 0.318, 0.462, 0.355, 0.355, 0.262, 0.173, 0.185, 0.020\}$$
$$\omega^{2005} = \{0.270, 0.209, 0.174, 0.217, 0.254, 0.257, 0.285, 0.222, 0.318, 0.274, 0.403, 0.238, 0.187, 0.340\}$$
$$\omega^{2006} = \{0.341, 0.203, 0.341, 0.213, 0.289, 0.310, 0.252, 0.265, 0.183, 0.199, 0.214, 0.186, 0.325, 0.329\}$$
$$\omega^{2007} = \{0.249, 0.242, 0.225, 0.223, 0.261, 0.246, 0.332, 0.226, 0.339, 0.292, 0.260, 0.163, 0.232, 0.374\}$$
$$\omega^{2008} = \{0.244, 0.227, 0.239, 0.258, 0.290, 0.275, 0.288, 0.293, 0.323, 0.283, 0.250, 0.180, 0.183, 0.351\}$$

Then, calculate the geometric average value of the above vectors as the common weight vector ω_j^*, namely the weight vector of the indicators.

$$\omega_j^* = \{0.199, 0.226, 0.128, 0.286, 0.241, 0.228, 0.272, 0.269, 0.275, 0.289, 0.276, 0.219, 0.203, 0.265\}$$

According to the importance of the fourteen indicators, we can rank them as x_{10}, x_4, x_{11}, x_9, x_7, x_8, x_{14}, x_5, x_6, x_2, x_{12}, x_{13}, x_1, x_3.

Where, "Total power of the owned construction equipment at the end of the year (x_{10})" has the highest contribution rate, the weight being up to 0.289. In contrast, "Total industrial output value (x_6)" has the lowest contribution rate, the weight being 0.128.

Secondly, calculate the comprehensive estimation values of development potential of China's construction industry in different years according to Eq. (2).

Thirdly, calculate the weight vector of the comprehensive estimation values according to Eq. (4).

$$\lambda^k = \{0.256, 0.355, 0.270, 0.309, 0.596, 0.277, 0.312, 0.334\}$$

Fourthly, calculate the comprehensive estimation values of development potential of China's construction industry during the nine years according to Eq. (3). See Table 2.

3.4 The Difference of Development Potential of Chinese Regional Construction Industry

In order to further analyze the difference of development potential among different regions, we summarized the means and standard deviations of development trend of Chinese regional construction industry (See Table 3). The east contains ten provinces, that is, Beijing, Tianjin, Hebei, Shanghai, Liaoning, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan and Shandong; The middle contains eight provinces, namely Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan; The west contains twelve provinces, that is Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Chongqing, Tibet and Xinjiang.

According to the above table, the nation and three regions(the east, the middle and the west) all reveal good development potential of the construction industry. It should be noted that the west has the greatest development potential, followed by the middle; compared with this, the east is the weakest. Besides, there is a decreasing trend of the standard deviations on the whole.

The above indicates that in the century, a "catching-up effect" occurred on the horizontal direction in the development process of Chinese construction industry. More specifically, all the regions of China began to extend the investment of fixed assets and attach importance to urban infrastructure construction, so as to culminate in the rapid development of regional construction industry. However, after the long period of the reform and opening up, the urban infrastructure construction in east is finally slowing down. In contrast, with the effective practice of "west development" and "middle rising", the middle and the west began to catch up with the east. Moreover, in either absolute or relative terms, the imbalances of the construction industry's development potential among the different regions are gradually narrowing.

4. Convergence Test of Development Potential of Chinese Regional Construction Industry

According to the above analysis, we can find among the different regions in China exist notable differences in development potential of construction industry. In order to describe the evolutionary trend of these discrepancies more comprehensively and dynamically, we apply the convergence theory to our study, and make a βconvergence test from two aspects: absolute convergence and club convergence.

4.1 Absolute β convergence test

β convergence represents a trend that the economy in poor regions increases faster than in developed regions, which is composed of absolute β convergence and conditional β convergence. And absolute β convergence refers to the equal long-time balance of economic development convergence in all regions. The precondition of convergence test is the overall identity among all regions except the initial capital amount. In other words, different regions have the same output value per capita, as well as the same rate of technical advancement, regulations and organizational techniques (Griliches, 1980). Currently, Chinese construction industry is on the critical transformation stage from the traditional planned economy to the modern marketing economy. With these typical features of the buyer's market, there is strong competition in this industry. Although, to a certain extent, resource containment exists in every region throughout the nation, the intense competition will surely lead to the mutual learning, renovation of management moods, and the expansion of technology resources in the whole country freely. Based on this, the construction industry almost conforms to the precondition of convergence test.

The regression model of absolute β convergence test is as follows:

$$\frac{1}{T}\log\left(\frac{y_{i,t}}{y_{i,t-T}}\right) = a + b\log\left(\frac{y_i^*}{y_{i,t-T}}\right) + \mu_{i,t} \tag{5}$$

where, a is the constant term; $y_{i,t}$ and $y_{i,t-T}$ are the productivities in the i region respectively in the periods of t and $t-T$; $\mu_{i,t}$ is the random error term; $b = \frac{1-e^{-\beta T}}{T}$, where β means the rate of convergence towards balance. If $b<0$, then $\beta>0$, which indicates that there exists absolute convergence in the region in the period of T. Otherwise, there is divergence in the region.

In accordance with Eq. (5), make the convergence test on the development potential of Chinese construction industry. And see Table 4 for the regression results.

First, according to DW value, it reflects that four models all pass the autocorrelation test, and haven't gone against the basic assumptions. So we can make the regression analysis further. Next, the rates of convergence are all over 10%. At the same time, R^2 in the models show a relatively strong explanatory power, and all reach the significance level of 0.05. Therefore, it shows that there exists an obvious absolute β convergence in the development potential of Chinese regional construction industry, which indicates the gap of the development potential among all the regions is gradually narrowing.

4.2 Club Convergence Test

Club convergence refers to a group of economic growths with similar original conditions and structure features converge to the same steady-state (Barro and Sala-I-Martin, 1991). Correspondingly, the regions existing club convergence are regarded as convergence club. Club convergence test mainly includes two steps: first, divide the sample regions into several groups, which are considered as convergence clubs to be tested; secondly, make the convergence analysis of all the groups, in order to test whether there exists club convergence phenomenon.

Due to the great differences in resource and policy environment among different regions, the development process of Chinese construction industry reflects an obvious imbalance. However, within a single region, it is easier to obtain convergence because of the uniformity of economic structure. According to the results of absolute β convergence test, there is convergence in the productivity of Chinese construction industry. Our question is: what is the internal structure of this convergence? In other words, do the club convergences exist in the three regions, namely the east, the middle and the west? Thus, we make further analysis of the development potential in the three regions with the absolute convergence model (Eq. 5). See Table 4 for the result.

The result shows there exists significant convergence phenomenon in the three regions and that is convergence clubs. Where, the rate of club convergence in the west is the highest up to 42.25%; the rate in the middle is 16.5%, higher than that of the nation; while the rate in the east is the lowest, only 13.3%, which is lower than the nation. The difference of the convergence rates reflects the imbalance in the development of Chinese regional construction industry. The development level in the east is far higher than that of the middle and the west, and it tends to be in a mature stage. Compared with this, the middle and the west, especially the latter, are still on the developing stage. On the whole, the convergence rate of construction industry is high, but

Table 4. Regression Results of the Convergence Test

	The nation	The east	The middle	The west
Constant term	0.034426*** (5.761322)	0.026171** (2.033717)	0.048197*** (8.952691)	0.037659*** (3.600588)
ln(x)	-0.095439*** (-6.945619)	-0.081929*** (-2.942886)	-0.091714*** (-7.400906)	-0.120746*** (-4.715689)
Rate of convergence β	0.180232	0.133183	0.165397	0.422557
Adjusted R-squared	0.611608	0.433767	0.884818	0.658785
F	48.24162	8.660579	54.77341	22.23772
DW	2.229611	2.06502	1.018386	2.778946

Note:***means being significant at 1% level, **means being significant at 5% level. Numbers inside the bracket are t-value.

with a big gap to the steady state. Chinese construction industry is still in the period of dramatic growth, which truly reflects the development of Chinese regional construction industry.

5. Conclusions

From the perspective of industrial development potential, this paper adopts multiple attribute model with time series, absolute convergence and club convergence models to do the empirical research on regional difference and spatial convergence of the development potential of Chinese construction industry in the new century. This method not only overcomes the weakness of the subjective weighting, but also reflects the evolution of the development potential and differences of Chinese regional construction industry more objectively and comprehensively. We find that in the new century, both the nation and the three regions have good development potential of the construction industry, and the gap between regions is getting narrow. The west has the greatest development potential, followed by the middle; compared with this, the east is the weakest. Moreover, there is absolute convergence in the development potential of the construction industry, and the three major regions have formed the convergence clubs. Based on the results, this paper puts forward some improvement measures: the east maintains stable development of the construction industry and drives the development of the middle and the west to promote balanced development among regions; in order to expand the market share of the construction products, introduce new technology and excellent management mode to the middle and the west, especially the latter; and improve their investment environment to attract foreign investment, thus enhancing the development potential of construction industry.

However, our research also has some limitations: due to the lack of some data, we cannot make analysis of the development potential of the regional construction industry in 2004. Because of the fairly long period of investigation, there are not great impacts on the results of absolute convergence and club convergence. China has a fairly vast territory, which results in the regional economic imbalance, including the imbalance of construction industry development. In future, we will further explore the forming mechanism and the dynamic evolution regulars of the development potential of Chinese regional construction industry.

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