A Study on the Competitiveness Level of the Construction Industry in 31 Provincial-Level Administrative Regions in China

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Abstract. To evaluate the competitive level of the construction industry in China, this paper constructs a comprehensive evaluation index system from four aspects: the scale competitiveness level, the efficiency competitiveness level, the market competitiveness level, and the stakeholders' competitiveness level. Utilizing relevant data from the 2022 China Statistical Yearbook, 31 provincial-level administrative regions in China are selected as the research objects, and factor analysis method is employed for assessment. The 31 provincial-level administrative regions in China can be classified into three categories: regions with high labor skills, regions with large industrial operation scale, and regions with relatively low labor efficiency and industrial scale. In terms of spatial distribution, provinces with higher levels of development and competitiveness in the construction industry are mostly located in the eastern coastal areas of China, as well as in the developed central and southern regions. These areas have relatively higher economic development levels, stronger government construction awareness, and more comprehensive construction industry standards and regulations compared to other regions. On the other hand, provinces with relatively lower levels of competitiveness in the construction industry are mainly situated in the southern, western, and northern border areas of China, where the development level is relatively lower.

Keywords: Competitive level of construction industry; Evaluation index system; Factor analysis; Evaluation

1 INTRODUCTION

The construction industry is advancing towards digital transformation, closely linked to regional economies, social environments, and influenced by factors such as policies, resources, and technology[1]. With the development of Industry 4.0 in recent years[2], the construction industry is gradually exploring the application of emerging digital technologies, leading to overall growth and competitiveness. However, due to the vast geographical diversity in China, the uneven development levels across different regions in the construction industry have resulted in varying competition levels. Therefore, in

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order to facilitate the modernization and digital transformation of the construction industry, it is necessary to quantitatively evaluate the competition levels of the construction industry in each province, providing a clearer assessment of the competition levels in each province and municipality[3]. This evaluation aims to help Chinese construction enterprises better understand their development status, leverage their competitive advantages, improve industrial economic efficiency, and enhance the international influence and competitiveness of the construction industry in China.

2 FACTORS INFLUENCING THE COMPETITION LEVEL OF THE CONSTRUCTION INDUSTRY

Many factors influence the competition level of the construction industry[4], including both internal and external elements. Regarding the competition level of the construction industry, typically only some core internal factors are considered, while certain micro-factors are often overlooked. Considering the characteristics of the construction industry, the impact on the comprehensive competition level of the construction industry is evaluated from three aspects: basic elements, external elements, and determinant factors.

(1) Basic elements. Basic elements mainly include natural environmental resources, sources of enterprise capital, and human resources. For a country, the vital advantage in developing industries lies in its natural environmental resources, such as land, forests, and water resources. Abundant scarce resources can somewhat reduce material acquisition costs, leading to higher profits. Construction projects have long construction periods, high quality requirements, and significant capital values involved[5], requiring substantial liquid and fixed assets to support construction. The capital value determines the industry's ability to participate in the market and its economic strength. Therefore, to further the development of enterprises, strong capital strength is essential.

(2) External elements. External elements refer to development factors outside the industry itself, mainly related to regulatory policy elements and the external market competitive environment[6]. Government policies concerning industry development are crucial for enhancing the competition level of the industry. Feasible and reliable industrial development policies can better guide industries towards the future. The smooth operation of industries depends on a favorable market environment, where enterprises can optimize resource allocation and achieve healthy development.

(3) Determinant factors. Internal factors within the industry determine the competition level of the industry[7], rather than external factors. With the advancement of Industry 4.0, the adoption of emerging digital technologies is intensifying competition in the construction market, rendering traditional strategies such as reducing industry costs to increase operational profits unfeasible[8]. True enhancement of industry competition level lies in the innovation and entrepreneurship capabilities of the industry itself. The quality of enterprises within the construction industry determines the level of industry competition. Management concepts, innovation levels of talent, and technological de-

velopment levels constitute the determinant factors of enterprises. Only by continuously improving the overall quality of internal enterprises can the comprehensive competition level of the industry be truly enhanced.

3 EVALUATION SYSTEM FOR THE COMPETITION LEVEL OF THE CONSTRUCTION INDUSTRY

3.1 Establishment of an evaluation index system

In order to accurately and clearly evaluate the competitive level of the construction industry in different provinces and cities in China, it is necessary to establish a corresponding evaluation index system. By combining the current development status of the construction industry in various provinces and cities in China, referencing existing research achievements in related fields, and following the principles of index system construction, this study selects relevant data on the construction industry from the 2022 "China Statistical Yearbook." The study focuses on the 31 provinces and cities in China as research objects, and constructs an evaluation system for the competitiveness level of the construction industry in different regions using four systemic indicators and twelve specific indicators, as detailed in Table 1. Overall, the competitiveness level of the construction industry is mainly manifested in the following four aspects:

Firstly, scale competitiveness level: The size of the industry can reflect its development status and overall strength. Based on historical data, the number of enterprises in the industry, the number of employees in the industry, the value of technical equipment in construction enterprises, and the annual output value of the construction industry can roughly reflect the scale of the construction industry.

Secondly, efficiency competitiveness level: Efficiency refers to the actual operational level and profit-making ability of relevant enterprises in the industry. The total asset value of the construction industry, labor productivity, and total profit obtained can roughly reflect the overall efficiency level of the construction industry.

Thirdly, market competitiveness level: Market competitiveness refers to the competitive ability of enterprises' construction projects in the construction market[9]. The construction area of buildings, completed building area, and total amount of contracted engineering projects can roughly reflect the market competitiveness level.

At last, stakeholders' level: Stakeholders refer to entities related to construction, such as survey and design units and construction units, whose operating income to a certain extent reflects the competitive level of the construction industry[10].

Table 1. Comprehensive evaluation index system of competition level in the construction industry

Target layer	System layer	Specific metrics	substitutability
Evaluation index	Scale competitiveness level	The number of enterprises	A1
		The number of employees	A2

of competition level of construction industry		The value of technical equipment	A3
		The annual output value	A4
	Efficiency competitiveness level	The total asset value, and	B1
		Labor productivity	B2
		Total profit obtained	B3
	Market competitiveness level	The construction area of buildings	C1
		Completed building area	C2
		Total amount of contracted engineering projects	C3
	Stakeholders' level	The operating income of the survey unit	D1
		The operating income of the supervision unit	D2

3.2 Data processing

The text processes relevant data obtained from the statistical yearbook to obtain the corresponding indicators required for the research. The factor analysis model used in this paper is as follows:

$$W_i = y_{i1}F_1 + y_{i2}F_2 + y_{i3}F3 + \ldots y_{im}F_m + z_i \text{ or } X_{(p\times 1)} = A_{(p\times m)}F_{(m\times 1)} + z_{(p\times 1)} \quad (1)$$

Where yij represents the factor loading, indicating the degree of dependency of Wi on Fj, A is the factor loading matrix composed of yij, and zi is the special factor affecting Wi. The scoring function for the i-th common factor is:

$$F_i = \sum b_{ij} W_i (i=1,2, \cdots, p; j=1, 2, \cdots, m) \quad (2)$$

Where bij represents the factors obtained in the matrix, Wi is the standardized indicator data. The numerical value of Fi is directly reflected in the score of the i-th common factor.

In this study, factor analysis was employed to process the various indicators, and further calculations were conducted using the standardized values. Factor analysis was carried out using IBM SPSS Statistics 26 software to comprehensively evaluate the level of competitiveness in the construction industry across 31 provincial-level administrative regions.

4 ANALYSIS RESULTS AND DISCUSSION

4.1 Scatter and Test of Correlation Matrix

Using factor analysis to standardize the 12 specific indicators under the 4 systemic indicators of the evaluation object, the correlation matrix shown in Table 2 is calculated.

Further, the relevant data is subjected to KMO test and Bartlett's sphericity test, with the results presented in Table 3. In Table 3, the KMO value for the partial correlation among variables in the correlation matrix is 0.793, the approximate chi-square value for Bartlett's sphericity test is 722.118, and the associated probability is 0.000. Therefore, the null hypothesis of variables being unrelated should be rejected, indicating that the original variables are suitable for factor analysis[11]. Factor analysis can be applied to evaluate the competitiveness level of the construction industry in various provinces[12].

Table 2. Correlation coefficient matrix

	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D1	D2
A1	1.000	0.871	0.795	0.868	0.659	-0.403	0.709	0.806	0.808	0.788	0.437	0.777
A2	0.871	1.000	0.883	0.939	0.604	-0.492	0.803	0.931	0.945	0.798	0.424	0.813
A3	0.795	0.883	1.000	0.917	0.702	-0.270	0.837	0.910	0.915	0.821	0.550	0.689
A4	0.868	0.939	0.917	1.000	0.817	-0.279	0.913	0.966	0.965	0.941	0.657	0.857
B1	0.659	0.604	0.702	0.817	1.000	-0.006	0.861	0.767	0.689	0.912	0.882	0.794
B2	-0.403	-0.492	-0.270	-0.279	-0.006	1.000	-0.192	-0.285	-0.298	-0.096	0.214	-0.258
B3	0.709	0.803	0.837	0.913	0.861	-0.192	1.000	0.892	0.873	0.863	0.721	0.771
C1	0.806	0.931	0.910	0.966	0.767	-0.285	0.892	1.000	0.975	0.877	0.651	0.827
C2	0.808	0.945	0.915	0.965	0.689	-0.298	0.873	0.975	1.000	0.848	0.540	0.752
C3	0.788	0.798	0.821	0.941	0.912	-0.096	0.863	0.877	0.848	1.000	0.797	0.887
	0.437	0.424	0.550	0.657	0.882	0.214	0.721	0.651	0.540	0.797	1.000	0.723
	0.77	0.81	0.68	0.85	0.79	-	0.77	0.82	0.75	0.88	0.72	1.00

7	3	9	7	4	0.258	1	7	2	7	3	0

Table 3. KMO test and Bartlett's sphericity test

The KMO value for the partial correlation among variables in the correlation matrix		0.793
Bartlett's sphericity test	The approximate chi-square value	722.118
	The degree of freedom	66

4.2 Calculate the eigenvalues and contribution rates of the correlation matrix

Following the principle of eigenvalues greater than 1, the factor analysis results in Table 4 indicate that the 12 indicators can be categorized into 2 factors, with a cumulative variance contribution rate of 88.833%. This effectively reflects the relevant information of the specific indicators. In extracting common factors, the contribution rate of components should reach 85%. Therefore, extracting two components for principal component analysis is appropriate[13].

Table 4. Total variance explained

Components	Initial eigenvalues			Extract the sum of squares of the load			Sum of squares of rotational loads		
	Summation	Variance %	Accumulation %	Summation	Variance %	Accumulation %	Summation	Variance %	Accumulation %
F1	9.118	75.982	75.982	9.118	75.982	75.982	8.168	68.065	68.065
F2	1.542	12.850	88.833	1.542	12.850	88.833	2.492	20.767	88.833
F3	0.510	4.253	93.086						
F4	0.311	2.593	95.679						
F5	0.205	1.712	97.391						
F6	0.121	1.005	98.396						
F7	0.079	0.662	99.059						
F8	0.067	0.558	99.617						
F9	0.034	0.284	99.901						
F10	0.007	0.059	99.960						
F11	0.003	0.028	99.988						
F12	0.001	0.012	100.000						

4.3 Rotated factor loading matrix

Due to the lack of clarity in expressing the meaning of factors in the original factor loading matrix, rotation is necessary to address this issue. By rotating the matrix, the variables will exhibit higher loadings on common factors and significantly different loadings on other factors, thereby enhancing the clarity of the common factors' essence. The resulting factor loading matrix is presented in Table 5.

From Table 5, it can be observed the computed rotated factor loading matrix. The first factor F1 shows large loadings on all indicators, indicating that F1 can effectively represent the competitiveness level in the construction industry. The second principal component, F2, demonstrates significant loading on labor productivity (B2), suggesting that F2 can represent the labor efficiency level in the construction sector.

Table 5. Component matrix after rotation

Index	Components	
	F1	F2
A1	0.718	0.544
A2	0.737	0.652
A3	0.811	0.431
A4	0.910	0.397
B1	0.944	-0.066
B2	0.042	0.887
B3	0.904	0.230
C1	0.881	0.406
C2	0.827	0.477
C3	0.962	0.143
D1	0.891	-0.325
D2	0.856	0.255

4.4 Factor scores and analysis

Based on the explanation of total variance, the component score coefficients in Table 4 and standardized variable data are calculated to obtain different scores F for each factor and rank them as shown in Table 6. The formula for calculating the composite score F is shown in Equation (3):

$$F = 0.681 \times F1 + 0.208 \times F2 \quad (3)$$

As shown in the calculation results in Table 6, Jiangsu ranks first as a strong province in construction, with a composite score exceeding 2. Two southern provinces, Dong and Zhejiang, rank second and third respectively. Following closely are the relatively strong developing regions of Beijing, Hubei, and Shandong in recent years. Hainan, Ningxia, and Tibet rank at the bottom three, possibly due to their relatively lagging development in comparison. According to the calculations, among the 31 provinces and municipalities, 12 regions have positive scores, indicating that the competitiveness of the construction industry in these areas exceeds the average level. Most of these 12 regions are located in the southeast, while the remaining 19 regions have negative scores and are mainly distributed in the central and western regions, showing regional characteristics with a pattern of strong performance in the east and lagging behind in the west.

Furthermore, from the results above, it can be observed that Jiangsu and Guangdong have significantly higher scores in the common factor F1 compared to other cities, which is the advantage that secures their first and second rankings. Zhejiang, Beijing, Hubei, Shandong, and Sichuan all have relatively high scores in F1, exceeding 0.5, indicating their advantages in construction scale and strong economic development. The cities ranking last, Hainan, Ningxia, and Tibet, have negative scores in F1 and show a considerable gap compared to the scores of other provinces and cities. This may be related to issues such as unreasonable industrial development structure, small market size, and lower industrial competitiveness in these regions. In terms of F2 scores, Jiangsu, Zhejiang, and Fujian stand out, indicating higher labor productivity in these provinces, allowing for the rational arrangement of industrial structure and leveraging labor advantages.

Table 6. Scores and rankings of the competition level factor of the construction industry in China's 31 provincial-level administrative regions

Province	F1	F2	F	Ranking	Province	F1	F2	F	Ranking
Jiangsu	2.667	2.366	2.310	1	Yunan	-0.523	0.404	-0.270	17
Guangdong	1.726	-0.284	1.120	2	Shanxi	-0.518	0.293	-0.290	18
Zhejiang	1.158	1.438	1.090	3	Tianjin	-0.387	-0.373	-0.340	19
Beijing	2.021	-2.587	0.840	4	Guangxi	-0.542	0.018	-0.370	20
Hubei	1.417	-1.288	0.700	5	Liaoning	-0.544	-0.110	-0.390	21
Shandong	0.917	0.022	0.630	6	Guizhou	-0.561	-0.246	-0.430	22
Sichuan	0.656	0.862	0.630	7	Xinjiang	-0.841	0.034	-0.570	23
Fujian	0.294	1.662	0.550	8	Gansu	-0.914	0.270	-0.570	24
Henan	0.217	0.919	0.340	9	Jilin	-0.748	-0.313	-0.570	25
Hunan	0.147	0.571	0.220	10	Heilongjiang	-1.089	0.433	-0.650	26
Shanghai	0.993	-2.278	0.200	11	Neimenggu	-0.969	-0.076	-0.680	27
Anhui	0.194	-0.014	0.130	12	Qinghai	-0.780	-1.008	-0.740	28
Shanxi	-0.019	-0.298	-0.070	13	Hainan	-0.839	-0.831	-0.740	29
Jiangxi	-0.268	0.209	-0.140	14	Ningxia	-1.269	0.562	-0.750	30
Chongqing	-0.426	0.690	-0.150	15	Xizang	-0.995	-0.409	-0.760	31
Hebei	-0.174	-0.641	-0.250	16					

5 CONCLUSION

This study focuses on the construction industry of 31 different provinces and municipalities in China, applying factor analysis to analyze the factors that can influence the competitiveness level of the construction industry. Subsequently, relevant data on the construction industry from the "China Statistical Yearbook 2022" are selected, and factor analysis is conducted using IBM SPSS Statistics 26 to derive two main components. The competitiveness scores and rankings of the 31 provinces and municipalities nationwide are then calculated. In general, the 31 provinces and municipalities in China can be roughly classified into three categories. Spatially, provinces and municipalities with higher levels of competitiveness in the construction industry are mostly located in the developed eastern coastal regions of China, while provinces with relatively lower levels of development in the construction industry are predominantly situated in the central and western regions. The reasons for this phenomenon may be related to the varying levels of development, technological advancement, policy support, and talent cultivation in different regions of China, all of which are factors that government decision-makers should pay attention to. Efforts should be initiated at the regional government level to enhance the competitiveness of the regional construction industry, emphasizing the optimal allocation of resources in the construction sector to maintain large-scale development. The quality of the workforce is a key factor influencing the competitiveness level of the construction industry. When recruiting employees, the construction industry should focus on enhancing the quality of staff and actively utilize advanced digital equipment to elevate the competitiveness of the local construction industry.

REFERENCES

1. Manzoor, B., Othman, I., & Pomares, J. C. (2021) Digital Technologies in the Architecture, Engineering and Construction (AEC) Industry—A Bibliometric—Qualitative Literature Review of Research Activities. International Journal of Environmental Research and Public Health, 18: 6135. https://doi.org/10.3390/ijerph18116135.
2. Kolb, J., Leible, S., Maslowski, L., & Schallmo, D. (2023) SUSTAINABILITY-ENABLED ASSESSMENT OF DIGITAL TECHNOLOGIES. International Journal of Innovation Management, 27: 2340003. https://doi.org/10.1142/S1363919623400030.
3. Baek, M., Ashuri, B., & Veeravenkatappa, S. (2022) Developing a Multivariate Time-Series Model to Forecast the Level of Competition in Transportation Projects. Construction Research Congress 2022. 283–291. https://doi.org/10.1061/9780784483978.030.
4. Nguyen Ngoc, H., Mohammed Abdelkader, E., Al-Sakkaf, A., Alfalah, G., & Zayed, T. (2023) A hybrid AHP-MAUT model for assessing competitiveness of construction companies: A case study of construction companies in Vietnam and Canada. Construction Innovation. https://doi.org/10.1108/CI-11-2022-0299.
5. Farhikhteh, S., Kazemi, A., Shahin, A., & Mohammad Shafiee, M. (2020) How competitiveness factors propel SMEs to achieve competitive advantage? Competitiveness Review: An International Business Journal, 30:315–338. https://doi.org/10.1108/CR-12-2018-0090.
6. Korkmaz, S., & Messner, J. I. (2008) Competitive Positioning and Continuity of Construction Firms in International Markets. Journal of Management in Engineering, 24: 207–216. https://doi.org/10.1061/(ASCE)0742-597X(2008)24:4(207).

7. Giménez, J., Madrid-Guijarro, A., & Duréndez, A. (2019) Competitive Capabilities for the Innovation and Performance of Spanish Construction Companies. Sustainability, 11: 5475. https://doi.org/10.3390/su11195475.
8. Hosseini, M. R., Banihashemi, S., Martek, I., Golizadeh, H., & Ghodoosi, F. (2018) Sustainable Delivery of Megaprojects in Iran: Integrated Model of Contextual Factors. Journal of Management in Engineering, 34: 05017011. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000587.
9. Zhao, Z.-Y., Guo, X.-L., & Chang, R.-D. (2019) Market Concentration and Competitive Intensity of the International Engineering Contracting Industry. Journal of Construction Engineering and Management, 145: 04019026. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001650.
10. Ali, A., Ma, L., Shahzad, M., Musonda, J., & Hussain, S. (2023) How various stakeholder pressure influences mega-project sustainable performance through corporate social responsibility and green competitive advantage. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-023-29717-w.
11. Alam, A., & Singh, A. (2023) Groundwater quality assessment using SPSS based on multivariate statistics and water quality index of Gaya, Bihar (India). Environmental Monitoring and Assessment, 195: 687. https://doi.org/10.1007/s10661-023-11294-7.
12. Asghari, S., Targholi, S., Kazemi, A., Shahriyari, S., & Rajabion, L. (2020) A new conceptual framework for identifying the factors influencing the effectiveness of competitive intelligence. Competitiveness Review: An International Business Journal, 30: 555–576. https://doi.org/10.1108/CR-05-2019-0054.
13. Ismail, M. Z., Mohamad Ramly, Z., Maaz, Z. N., & Abdul Rahim, F. N. (2023) Assessment of Cost Influences in Rail Projects from Contractor's Perspectives. International Journal of Built Environment and Sustainability, 11: 75–84. https://doi.org/10.11113/ijbes.v11.n1.1204.