Comprehensive Evaluation of International Market Competitiveness Based on ANP-Grey Theory

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Abstract. This study is aimed at formulating competitiveness index system for Chinese medium-sized construction enterprises entering overseas international construction markets and evaluate a company's competitiveness by adopting grey theory. An analytic network process (ANP) method is adopted to establish a set of competitiveness index system for medium-sized construction enterprises. Subsequently, grey correlation analysis is used to evaluate competitiveness relative to that of other enterprises based on limited available information. Through expert evaluation and ANP, the weights of the index system are calculated, and indicators with the highest weights are identified. The top five indicators are industry structure, industrial organization status, brand resources, enterprise system, and enterprise size. A case study is conducted, and the following conclusions are drawn that using grey correlation analysis and the competitiveness system, enterprises can judge their competitiveness level against that of rivals in the international market. This study can help Chinese medium-sized construction enterprises evaluate their international market competitiveness through expert evaluation methods, the ANP, and grey correlation analysis in a comprehensive and innovative manner.

Keywords: Competitiveness · analytic network process · grey theory · medium-sized enterprises · international market

1 Introduction

The construction industry is an important part of China's national economy. In the past decade, many construction enterprises have emerged rapidly, including not only large and mature enterprises but also small and medium-sized enterprises (SMEs). Despite the stable development of Chinese construction enterprises, the scale level thereof is uneven. Enterprises face a complex and diversified market competition environment. Since the "One Belt, One Road" initiative in 2013, infrastructure construction has been supported at China's national level, whereby many barriers have been cleared to enable construction enterprises to enter the international market. However, different types of construction enterprises face different degrees of difficulty in developing overseas markets. Overseas construction projects are characterized by the complexity of large funds, long time

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spans, and uncertain construction periods. Large-scale contractors have strong risk-taking abilities to endure overseas projects failing. By contrast, medium-sized contractors have weak risk-taking abilities, as any project decision-making error may be fatal to company survival. Therefore, to enter the international market, these medium-sized contractors need to develop their competitiveness to be able to outdo rival enterprises.

Compared with large-scale enterprises which have been researched thoroughly on problems of internationalization by many studies, medium-sized construction enterprises have drawn less attention on their competitiveness, such as constructing an index system and evaluating the contribution of competitiveness factors to SMEs' competitive advantages [4], or analysing the influence of competitiveness on the performance and development of SMEs [13]. Moreover, these previous studies overlooked practical applicability for SMEs to enter international markets, which requires an appropriate evaluating index system and corresponding information of SMEs. Especially the information is usually with grey characteristics and is partially known and partially unknown.

Therefore, this study aims to formulate a competitiveness index system for medium-sized enterprises entering the overseas international construction market and to evaluate a company's competitiveness by adopting grey theory in a case study. Specifically, this study attempts to solve two problems for medium-sized construction enterprises:

a) identifying competitiveness indicators with high weights;
b) comparing competitiveness among competing enterprises.

This study will help small and medium-sized construction enterprises have a better understanding of their competitiveness level and enhance their competitiveness accordingly. After thorough comparison, the construction enterprises can then formulate strategies to overcome rivals in the international market.

2 Literature Review

2.1 Enterprise Competitiveness Theory

Research on enterprise competitiveness began in the early 1980s and can be divided into three schools: a) the structural school, which focuses on the industrial choice of competitive strategy and the analysis of competitors [14]; b) the competency school, which focuses on the behavioural and process analysis theory of competitive strategy [15]; c) the resource school, which focuses on the comprehensive theoretical analysis framework of competitive strategy [19]. Enterprise competitiveness is the competitive advantage of enterprises in the industry (Porter, 1985), not only related to efficiency within the enterprise but also subjects to the international environment.

Research on the competitiveness of construction enterprises adopts the theories of the three schools and enterprise competitiveness index systems and models have been established diversely. From the competency school perspective, Budayan et al. (2020) [1] established a framework including twelve macro level parameters concerning cost management in order to help construction enterprises improve their competitiveness. From the perspective of resource school, Wang et al. (2016) constructed an evaluation index system including four dimensions of enterprise strategy, organization scale, enterprise

culture, and enterprise resources for electric power construction enterprises. From the structural school perspective, classical models such as value chain theoretical framework [9], and extended diamond model [6] have been applied to proposed specific strategies to enhance competitiveness of construction enterprises.

Other scholars focused on evaluating the influence of single parameter on the competitiveness of enterprises, such as cooperative network establishment [8] and investment decisions under the scenario of game between enterprises [7].

Overall, previous studies have mainly focused on evaluating the competitiveness of construction enterprises in domestic markets, neglecting the international market and enterprises of different sizes. One main deficiency of these studies is that current competitiveness index systems might not be suitable under the circumstances that medium-sized construction enterprises entering international market. Another deficiency is that the methods adopted in calculating the competitiveness of enterprises such as location quotient [22] and fuzzy ANP [17], might not be suitable for medium-sized construction enterprises with small data and partially known, partially unknown information.

2.2 Analytic Network Process Method

The analytic network process (ANP) extends the analytic hierarchy process (AHP) by fully considering the interaction between elements or adjacent levels. The ANP can cover both intangible and tangible indicators, which is an effective approach to integrate different views of decision-makers and reach a consensus [16]. The ANP is suitable for prioritization of factors in a framework [12].

The ANP can also be combined with many other methods. By utilizing ANP and Monte Carlo simulation, competitive contractors could be prioritized at the pre-bidding stage [3].

2.3 Grey System Theory

Grey system theory is a method for studying uncertainty of small data and poor (partially known, partially unknown) information. It mainly involves extraction of valuable information by mining partially known information and enables correct description and effective monitoring of the system's operation behaviour and evolution law [11].

Grey system theory has been widely applied. Combined with AHP, grey correlation analysis has been applied to establish a subcontractor selection model considering the actual requirements of construction enterprises [2], and grey clustering evaluation has been applied to build a comprehensive risk assessment model, which helps to provide suggestions for the project manager [20]. Furthermore, grey correlation analysis has also been used to evaluate the competitiveness of enterprises in different industries, such as construction industry [5] and pharmaceuticals (Pan et al., 2016).

Previous studies have shown that grey system theory is appropriate for evaluating enterprise competitiveness. Considering that the information of medium-sized construction enterprises is partially known, this study applies grey correlation methods in a case study.

3 Method

This study adopts an ANP method to establish a competitiveness index system for medium-sized construction enterprises based on the three schools of enterprise competitiveness. Then this study uses grey correlation analysis in a case study to evaluate competitiveness of a medium-sized construction enterprise relative to that of other enterprises based on limited available information.

3.1 Competitiveness Index System

This research draws on the structural, resource, and competency schools of competitive strategy, and establishes a competitiveness index system. It can help construction enterprises understand their own competitiveness level and compare it with that of rivals in the international market.

The competitiveness index system considers the three schools of enterprise competitiveness as first-level indicators. This specific system is designed to reflect the macro dimension of international competitiveness and compare enterprises across the international market. By collecting and classifying indicators frequently applied in the literature on competitive construction enterprises in the international market, this research establishes 14 second-level indicators. Enterprise structure includes two indicators: industrial organizational status and industry structure. Enterprise resources include four indicators: enterprise size, brand resource, enterprise system, and partnership. Enterprise competency includes eight indicators: market capability, profitability, technical capability, operational capacity, internationalization capacity, project management capability, financing capacity, and sustainable development capacity. The specific contents are shown in Table 1.

The Super Decisions software is used to construct ANP network models and implement ANP operation for the index system according to the ANP principle and Delphi methods. The ANP network model is shown in Fig. 1.

3.2 Data Collection

The questionnaire was e-mailed to Chinese medium-sized contractors with extensive experience or high positions in international construction projects. A total of 25 experts were provided with a questionnaire containing the judgment matrices. These experts have a deep understanding of China's medium-sized construction enterprises and an average of over 10 years' overseas construction experience. 16 of the 25 questionnaires were collected from March 2019 to May 2019. The raw data has been checked for consistency, thus was valid.

3.3 Weight Calculation Results

The weight of each indicator in the competitiveness index system is calculated and confirmed by ANP adopting the Super Decisions software. The results are shown in Table 2.

Table 1. Evaluation indicators of competitiveness.

First-level	Second-level
Enterprise structure A	Industrial organizational status A1
	Industry structure A2
Enterprise resources B	Enterprise size B1
	Brand resources B2
	Enterprise system B3
	Partnership B4
Enterprise competency C	Market capability C1
	Profitability C2
	Technical capability C3
	Operational capacity C4
	Internationalization capacity C5
	Project management capability C6
	Financing capacity C7
	Sustainable development capacity C8

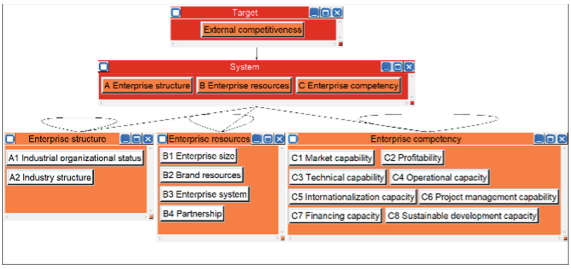

Fig. 1. Framework of competitiveness indicators.

Table 2 shows that enterprise competency has the highest weight of the first-level indicators (0.4038), followed by enterprise resources (0.3784) and enterprise structure (0.2178). Furthermore, the top five second-level indicators are industry structure, industrial organization status, brand resources, enterprise system and enterprise size. These indicators cover enterprise scale, output value, brand, and system.

Industry structure is of most importance to enterprises, as an increasing number of contractors entering the international market has triggered changes in market structure and intensified competition [21]. In this situation, organization status (Parnell et al., 2015) and enterprise size and scale [18] should help enterprises survive and expand international market. After entering international market and gaining basic market share, enterprises could take variable tactics [10] such as cultivating leadership, adjusting enterprise system, and strengthen enterprise reputation to further enhance their competitiveness.

Table 2. Weights and rankings of competitiveness indicators.

First-level	Weight	Second-level	Relative weight	Total weight	Ranking
Enterprise structure	0.2178	A1 Industrial organizational status	0.4950	0.1078	2
		A2 Industry structure	0.5051	0.1100	1
Enterprise resources	0.3784	B1 Enterprise size	0.2568	0.0972	5
		B2 Brand resources	0.2845	0.1077	3
		B3 Enterprise system	0.2583	0.0977	4
		B4 Partnership	0.2004	0.0758	6
Enterprise competency	0.4038	C1 Market capability	0.1566	0.0632	8
		C2 Profitability	0.1638	0.0661	7
		C3 Technical capability	0.1528	0.0617	9
		C4 Operational capacity	0.1302	0.0526	10
		C5 Internationalization capacity	0.1119	0.0452	11
		C6 Project management capability	0.0983	0.0397	13
		C7 Financing capacity	0.0878	0.0354	14
		C8 Sustainable development capacity	0.0987	0.0399	12

4 Case Study

4.1 Grey Correlation of Enterprises

The case study focuses on Company A, a medium-sized construction enterprise in China. This section compares Company A with two other medium-sized construction enterprises, namely Company B and Company C, which are international competitors in the same business field. All three companies' financial and other relevant data in 2016 were collected as the original data for grey correlation analysis.

Because the data required for some competitiveness indicators could not be obtained, the competitiveness index system was adjusted and the remaining indicators were scored through expert evaluation. The combined weights of the indicators in the revised system still amount to 100%.

Table 3. Revised weights and rankings of competitiveness index system.

First-level	Weight	Second-level	Relative weight	Total weight	Ranking
Enterprise structure	0.2178	Industrial organizational status	0.4950	0.1078	5
		Industry structure	0.5051	0.1100	4
Enterprise resources	0.3784	Enterprise size	0.3418	0.1293	2
		Brand resources	0.3629	0.1373	1
		Enterprise system	0.2954	0.1118	3
Enterprise competency	0.4038	Market capability	0.2450	0.0989	6
		Profitability	0.2301	0.0929	7
		Technical capability	0.2120	0.0856	8
		Internationalization capacity	0.1787	0.0722	9
		Financing capacity	0.1344	0.0543	10

The revised index system includes three first-level indicators of enterprise structure, enterprise resources and enterprise competency and 10 second-level indicators. The weights of each indicator in the revised index system are calculated as shown in Table 3.

A software GSTA7.0 is used to obtain the results of Deng's grey correlation degree. In the revised competitiveness index system, the units of the second-level indicators differ, so the original data of the three companies need to be averaged. To obtain a dimensionless data matrix, the values of the three companies for the same second-level indicator are compared with the average values of the three companies for the given indicator. Then, the highest value of three companies for each second-level indicator is taken to form an idealized reference sequence. The competitiveness of the three companies can be judged by calculating Deng's correlation degree with the reference sequence.

The weight of each indicator is added to the calculation of the correlation degree, which differs from the calculation of Deng's correlation degree using the normal mean value, whereby more accurate evaluations of the three companies' competitiveness can be obtained. The results are listed in Table 4.

4.2 Discussion of Grey Correlation

In the revised competitiveness index system, the top five indicators by weight are brand resources, enterprise size, enterprise system, industry structure, and industrial organizational status. These five indicators have the strongest influence on the correlation results.

Company C has the highest Deng's correlation degree with the idealized reference sequence, followed by Company A and Company B. Generally, Company C is the most competitive of the three, with a lead in almost all the indicators for which data are available.

Table 4. Results for Deng's correlation degree and weighted correlation Degree.

Measurement	Company		
	A	B	C
Industrial proportion	1.0000	1.0000	1.0000
Gross revenue	0.4760	0.4499	1.0000
Total number of employees	0.4583	0.5855	1.0000
Popularity of the enterprise	0.6837	0.3485	1.0000
Quality management system	1.0000	0.5733	0.5379
Overseas market quantity	0.4559	0.6340	1.0000
Profit growth rate	0.7603	0.6235	1.0000
Number of patents	1.0000	0.4827	0.5458
Number of overseas branches	0.4106	0.3333	1.0000
Bank credit rating	1.0000	0.3817	1.0000
Deng's correlation degree	0.7245	0.5412	0.9084
Weighted correlation degree	0.7103	0.5516	0.9095

Company A ranks the second in terms of performance, scoring highest in terms of quality management system and number of patents. However, it has insufficient overseas institutions to compete with the other two companies. Company B ranks third, with its data strongly constrained to average levels, demonstrating that it has few outstanding indicators.

Considering Deng's correlation degree, the averaged data, and indicator weights, two specific strategies could be drawn for Company A. Firstly it should maintain the current high level of its quality system and technological advantages. By improving product quality, delivering products on time, and flexibly responding to customer needs, it can hopefully achieve competitiveness improvements [17]. Secondly, it should expand its business scale, especially in overseas markets, and raise the income level. As is shown in Sect. 3, organization scale is the foundation for medium-sized construction enterprises to enter and expand international markets.

5 Conclusions

Focused on medium-sized Chinese enterprises entering the international construction market, this study combines relevant theories on competitiveness of enterprises with the actual situation in a case study, and develops a competitiveness index system especially for medium-sized construction enterprises.

Using expert evaluation and the ANP, this study calculates the weights of the index system and identifies the indicators with the highest weights. The top five indicators of competitiveness system are industry structure, industrial organization status, brand resources, enterprise system, and enterprise size.

By using grey correlation analysis and competitiveness index system as a reference, this study judges competitiveness level of a medium-sized construction enterprise against that of rivals in the international market. The case study reported herein confirm the aforementioned aspects. Based on grey theory and the competitiveness index system, this study can help Chinese medium-sized construction enterprises enhance competitiveness in the international construction market.

The contribution and novelty of this study lies in the comprehensive use of expert evaluation methods, the ANP, grey correlation theory, and establishing a set of comprehensive indicators for systematically evaluating competitiveness.

This study, however, has several limitations. The index system is especially suitable for medium-sized construction enterprises in China. Therefore, their potential application to large-scaled construction enterprises remains to be verified. Moreover, the validity of the findings from the case study is affected by the small number of sample companies. As there are various types of medium-sized construction enterprises, future research could shift focus from one single company to a specific group of enterprises. It will be encouraging that continuous research on several companies could be conducted over time, or a larger number of companies could be analysed. Such research would yield more pertinent and convincing results.

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