Competitiveness Evaluation of International Contractors Based on Back Propagation Neural Network

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Keywords: International Contractors, Competitiveness Evaluation, Back Propagation (BP), Neural Network, Engineering News-Record (ENR)

SUMMARY

The global high-speed rail network is rapidly expanding across continents worldwide. In 2009 the Obama administration proposed the integration of high-speed rail plans to expand the transportation network in the United States. A new round of international transport market competition is about to occur. Chinese contractors should seize opportunities in the high-speed rail market of the United States and do adequate technical and market preparation for entering the markets of developed countries in Europe and America as the top international contractors. The purpose of this paper is to discuss this issue from the perspective of international competitiveness of international construction contractors. Firstly, the paper establishes a model to evaluate competitiveness of international contractors through three first-level indexes and 11 second-level indexes. Then we build a quantitative evaluation model of competitiveness by Back Propagation Neural Network for international contractors and choose 123 contractors from Engineering News-Record reports to test the effectiveness of the proposed model. The results are as follows: 1） Most of the Chinese contractors belong to the third level of market as market chasers; 2) Compared to Bechtel, one top international contractor from the U. S., China Railway Construction Corporation has almost equal abilities in market development and sustainability, but China Railway Construction Corporation is far weaker in international expansion; 3) The overall performance of China Railway Construction Corporation in 2013 is weaker than in 2011 and 2012.

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1. INTRODUCTION

The global high-speed rail network is rapidly expanding across continents worldwide. In 2009 the Obama administration proposed the integration of high-speed rail plans to expand the transportation network in the United States. A new round of international transport market competition is about to occur. Chinese contractors should seize opportunities in the high-speed rail market of the United States and do adequate technical and market preparation for entering the markets of developed countries in Europe and America as the top international contractors. In the past decade, the total turnover of the top 225 international contractors has increased by 263%, from $139.8 billion in 2003 to $507.5 billion in 2012. The traffic projects are the largest proportion, accounted for 25.6% of the total market, a total of $129.9 billion. Thus there are many opportunities for the traffic contractors in the international contracting market in the future.

This study discusses the competitiveness of the international engineering contractors from the perspective of international competitiveness. At first we establish the international contractors' competitiveness evaluation model by 3 first level indicators and 11 secondary indicators. A quantitative competitiveness evaluation model of the international contractors is set up through the Back Propagation (BP) neural network. We choose 123 contractors from the "Engineering News Record" to test the validity of the model. The research conclusion is as follows: 1) Most Chinese contractors in the market belong to the third phase as the chaser of the market; 2) compared with Bechtel, one of the top contractors in the U.S., China Railway Construction Corporation demonstrates almost the same market developing and sustainable development abilities , but the international market developing ability has lagged far behind; 3) compared with that in 2011 and 2012, the overall performance of China Railway Construction Corporation in 2013 is weaker.

2. LITERATURE REVIEW

2.1 The Elements of Competitiveness

Although numerous domestic and foreign scholars have carried out extensive research on enterprise competitiveness from the perspective of their own views, there is no unified understanding of this measurement. There are three major mainstream schools for enterprise competitiveness: the market structure school popularized by Porter (1985), Wemerfelt's resources school (1984), and the ability school represented by C.K. Prahalad and Hamel (1990). The theoretical research of competitiveness started late in China, and there is still controversy for the composition and evaluation of competitiveness, so there is no complete theoretical system. Zhou discusses the relationship between sustainable development and competitiveness of a contractor, and he thinks the contractor's competitiveness mainly consists of information, strategy and wealth abilities (2009). Xie maintains that both enterprises and projects need to be considered at the same time for the contractor's competitiveness, including core technical capabilities, human resources, market development ability, organization, management ability and project management and implementation capacity (2010). Huang analyzes the competitiveness of a contractor through comparative study of hydropower contractors at home and abroad, and he thinks that the competitiveness of the contractor includes strategy, organization, market, culture, innovation, environmental adaptation, etc (2011). In summary, the constituent elements of enterprise competitiveness are inseparable from the notions represented by the three mainstream schools: enterprise capability, enterprise resources and enterprise competitive environment. This research will discuss from these three elements of the competitiveness of the international contractors.

2.2 Competitiveness Evaluation

Competitiveness evaluation is one of the important topics of competitiveness. Two of the most influential international institutions, the WEF (World Economic Forum) and IMD (International Institute for Management Development), both in Switzerland, use the comprehensive index evaluation method. Other mainstream evaluation methods include gray comprehensive analysis (Hu, 2003), the data envelopment analysis (Liu, 2001), factor analysis (Wang, 2008), and fixed weight analysis (Li, 2003), etc. Gray comprehensive evaluation does not need a large number of samples, but it requires that the sample data has a time series characteristic. Data envelopment analysis uses the method of data planning to evaluate the competitiveness from the perspective of the outcome. Factor analysis reduces multiple indicators to a small number of unrelated and unobservable random variables. Fixed weight sorting is derived from the one-third method of the IMD world competitiveness yearbook. The last two methods need simple operation, but the results are not precise enough. Combining the comprehensive index method with the analytic hierarchy process (AHP), this study uses the BP (Back Propagation) neural network as the research method.

3. METHODOLOGY

3.1 The Evaluation Index System

Based on previous research and the characteristics of international contractors, this study considers that competitiveness of contractors as the ability which makes the international contractors more likely to obtain project contracts and profitability than other contractors, taking into consideration the company's own development of comprehensive factors. Since this paper mainly studies the international contractors' competitiveness for the high-speed railway system in the U. S., we increase the value of the market segmentation index of traffic project to increase the specificity of evaluation index. Combining the sustainable developing view (Zhang, 2012) and dual dynamic capability view (Zhao, 2013) this paper focuses on the contractor's internationalization ability, market development ability, market segments ability and sustainable ability when evaluating enterprise competence. Enterprise resources include tangible and intangible resources using the general classification method. The competition environment is not limited to the enterprise's macro environment but also includes the internal micro environment. The complete form of a contractor's competitiveness was displayed in Figure 1.

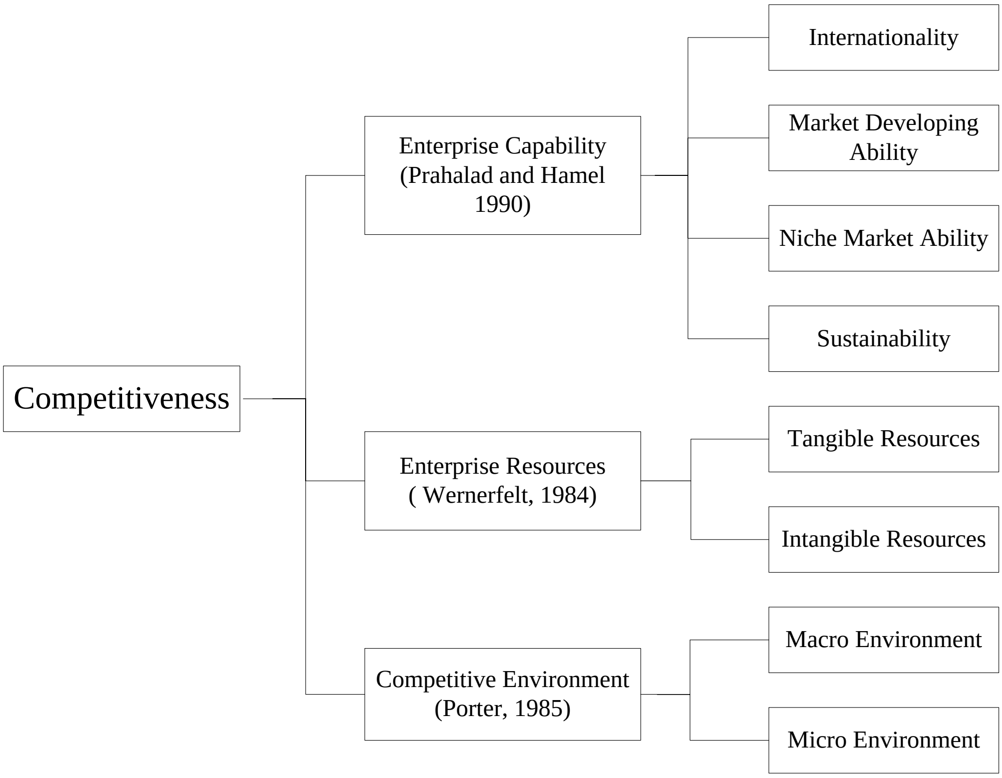

Fig. 1 The components of contractor competitiveness

3.2 The BP neural network structure

BP artificial neural network is one of the most widely used neural network model. Its main characteristic is that the implicit layer can be used to solve nonlinear problems. The BP artificial neural network model built by this article consists of three layers of neurons, including a hidden layer, as shown in Figure 2. A hidden layer is established to fit the characteristics of our sample data and prevent the over fit phenomenon. The number of neurons in the input layer corresponds to the number of evaluation index, while the number of neurons in the output layer corresponds to the evaluation target for this article, namely the competitiveness index.

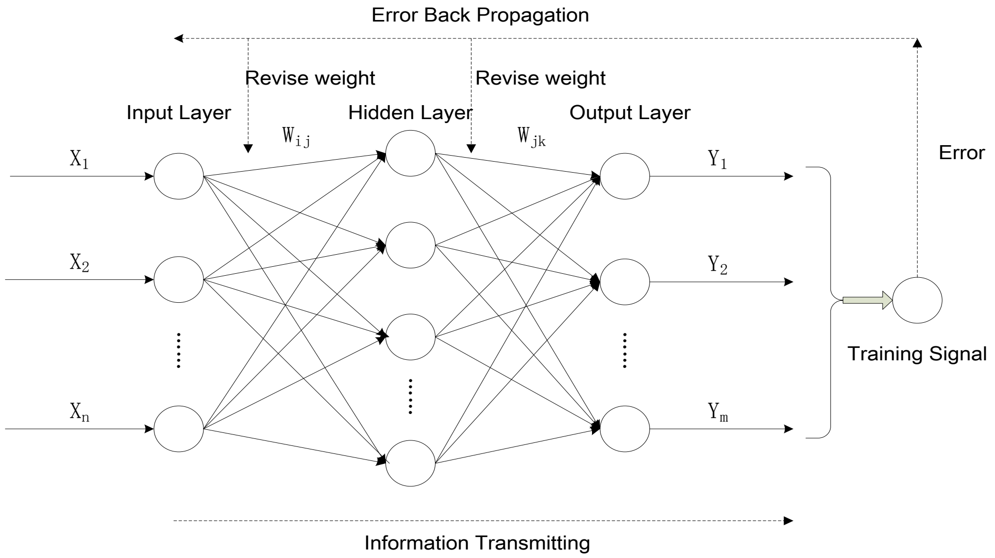

Fig. 2 BP neural network model

3.3 BP Algorithm

The algorithm of BP artificial neural network training process includes the following steps:

Step 1: initialize the network.

Determine n, the number of neurons in the input layer and m, the number of neurons in the output layer according to the sizes of the sample input and output data. Assign 1 to the number of neurons in the hidden layer. Initialize weights ω_{ij}, ω_{jk} and threshold values a and b, and determine the learning rate and the excitation function f (x). The incentive function in this paper is the Sigmoid function.

$$f(x) = \frac{1}{1+e^{-x}}$$

Step 2: calculate the hidden layer output

$$H_j = f(\sum_{j=1}^{n} \omega_{ij} x_i - a_j) \quad \text{j=1, 2… } l$$

Step 3: calculate output layer output

$$O_k = \sum_{j=1}^{l} H_j \omega_{jk} - b_k \quad \text{k=1, 2… m}$$

Step 4: calculation error

$$e_k = Y_k - O_k \quad \text{k=1, 2… m}$$

Step 5: fixed weights

$$\omega_{ij} = \omega_{ij} + \eta H_j (1 - H_j) x_i \sum_{k=1}^{m} \omega_{jk} e_k \quad \text{i=1, 2… n, j=1, 2… } l$$

$$\omega_{jk} = \omega_{jk} + \eta H_j e_k \quad \text{j=1, 2… l, k=1, 2… m}$$

Step 6: fixed threshold

$$a_j = a_j + \eta H_j (1 - H_j) \sum_{k=1}^{m} \omega_{jk} e_k \quad \text{j=1, 2… } l$$

$$b_k = b_k + e_k \quad \text{k=1, 2… m}$$

Step 7: Determine whether the computation is done. If not, then return to Step 2

4. CASE STUDY

4.1 The Sample

To evaluate competitiveness of the contractor, we need detailed and accurate materials of the contractor. We obtain the company information of the contractors from American McGraw hill ENR report. We select the 2013 ENR250 and 2012 ENR225 annual reports as the data source. After detailed screening and statistics, 123 traffic contractors are selected as the research samples, which were numbered from A1 to A123, respectively, according to the ENR ranking in 2013.The samples are shown in Table 1. Due to the limited space, this article lists only part of the sample and the sample parameter values.

Table 1 Research Sample

Number	Company
A1	Grupo ACS, Madrid, Spain
A2	HOCHTIEF AG, Essen, Germany
A3	Bechtel, San Francisco, Calif., U.S.A.
A4	VINCI, Rueil-Malmaison, France
A5	Fluor Corp., Irving, Texas, U.S.A.
A6	STRABAG SE, Vienna, Austria
A7	BOUYGUES, Paris, France
……	……
A117	Sener Ingenieria y Sistemas SA, Las Arenas (Getxo), Vizcaya, Spain
A118	MAKYOL Constr. Indus. Tourism & Trading Inc., Istanbul, Turkey
A119	Energoprojekt Holding PLC, Belgrade, Serbia
A120	Aecon Group Inc., Toronto, Ontario, Canada
A121	GAP Insaat Yatirim ve Dis Ticaret AS, Istanbul, Turkey
A122	STFA Construction Group, Istanbul, Turkey
A123	Tutor Perini Corp., Sylmar, Calif., U.S.A.

4.2 Competitiveness Index

The study uses X1 - X11 to represent the secondary indicators that are used as the source of the elements of competitiveness identified earlier in this paper. We employ: international sales (represented by X1), and international revenue growth (represented by X2) as indicators of internationalization ability. Market development ability, is indicated by the new contracts (X3) and new contract growth (X4). Transportation niche market ability is indicated by the international transport market sales (X5) and transportation market growth (X6). Sustainability is indicated by the gross sales growth (X7). Tangible resources and intangible resources are given by gross sales (X8) and the brand value (X9). Last but not least, the macro environment, mainly concerning the company-host country is indicated by X10 and the micro environment which refers to the proportion of the transportation projects sales of the contractor is indicated by X11. Data of international sales, new contract turnover, international transport market and total turnover can be obtained directly from ENR. International sales growth rates, and transportation market growth rates can be computed by comparing the operation for two consecutive years. In addition, brand value is scored based on ENR ranking: the five points for the top 50 is, four points for those ranked 51-100, three points for those ranked 101-150, two points for those ranked 151-200, and one point for those ranked 201-250. Moreover, the host country is a virtual variable. Since this paper treats the high-speed rail market in the United States as the target market, the value of X10 (host country) for enterprises from the United States is 1, while X10 for enterprises from other countries is 0. Data collection results are shown in Table 2.

Table 2 Sample Data

Number	X1-International sales ($ MIL)	X2-International sales growth	X3-New contracts ($ MIL)	X4-New contracts growth	X5-Transportation market sales($ MIL)	X6-Transportation market sales growth	X7-Gross sales growth	X8-Gross sales ($ MIL)	X9-Brand value	X10-Host country	X11-Proportion of transportation(%)
A1	42772.00	0.37	43658.80	-0.53	10693.00	0.32	0.20	50654.60	5	0	25
A2	34563.30	0.08	37673.00	0.10	7258.29	-0.05	0.08	36452.70	5	0	21
A3	23255.00	0.39	12926.00	-0.73	6743.95	0.35	0.18	29436.00	5	1	29
A4	18419.50	-0.01	18854.30	-0.62	9209.75	-0.03	-0.04	50338.70	5	0	50
A5	17209.60	0.27	20600.00	-0.23	1720.96	1.54	0.20	22352.80	5	1	10
A6	16062.00	-0.07	15271.00	0.23	8191.62	-0.03	-0.08	18557.00	5	0	51
A7	14196.00	0.13	14538.00	-0.58	8517.60	0.13	0.07	33885.00	5	0	60
……	……	……	……	……	……	……	……	……	……	……	……
A117	199.00	-0.23	173.40	-0.77	17.91	0.73	-0.40	449.70	1	0	9
A118	195.20	0.01	30.20	-0.93	195.20	0.01	0.05	645.10	1	0	100
A119	162.30	-0.04	253.70	-0.06	60.05	-0.06	0.11	288.10	1	0	37
A120	157.90	-0.35	66.70	-0.97	74.21	-0.44	0.02	2961.80	1	0	47
A121	146.20	-0.56	105.50	0.52	70.18	-0.48	-0.56	146.20	1	0	48
A122	139.00	-0.38	180.00	-0.63	122.32	-0.40	-0.20	196.90	1	0	88
A123	129.70	-0.27	277.90	-0.89	12.97	-0.19	-0.07	4095.90	1	1	10

4.3 Index Weight Calculation

The paper uses Analytic Hierarchy Process (AHP) to determine the index weights, combined with expert advice; we establish the judgment matrix for grade indexes and then determine the consistency of the judgment matrix. Judgment matrix in this paper passed the consistency check. The weight of the primary index and the secondary indexes and the synthesis weights multiplied by the two weights are shown in Table 3.

Table 3 Evaluation Index System

Competitiveness Index	First Grade Index	Weight of Fist Grade	Elements	Second Grade Index	Weight of Second Grade	Synthetical Weight
Contractor Competitiveness	Enterprise Capability	0.57	Internationality	X1-International sales	0.29	0.1656
				X2-International sales growth	0.15	0.0828
			Market Developing Ability	X3-New contracts	0.06	0.0359
				X4-New contracts growth	0.06	0.0359
			Niche Market Ability	X5-Transportation market sales	0.29	0.1656
				X6-Transportation market sales growth	0.07	0.0398
			Sustainability	X7-Gross sales growth	0.08	0.0442
	Enterprise Resources	0.29	Tangible Resources	X8-Gross sales	0.5	0.1450
			Intangible Resources	X9-Brand value	0.5	0.1450
	Competitive Environmen t	0.14	Macro Environment	X10-Host country	0.67	0.0933
			Micro Environment	X11-Proportion of transportantion	0.33	0.0467

4.4 Artificial Neural Network Training

This research uses the Matlab mapminmax function to normalize the data. Data after normalization distribute in the intrval [0, 1] and the normalized results are shown in Table 4. After the normalization the data are multiplied by the weight of each index for aggregation to get the Competitiveness Index (CI). By using the normalized data as the input and CI as the output, the network can be trained to learn the inherent nonlinear law among the data.

The paper uses the Matlab software to construct artificial neural network and achieve the BP artificial neural network algorithm. In the input layer of the neural network there are 11 neurons corresponding to the 11 evaluation indexes of the sample. In the hidden layer there are 9 neurons. In the output layer there is one neuron corresponding to the competitiveness evaluation index CI. The maximum number of iterations is set to 1000 times, training target accuracy is 0.0001, and the learning rate is 0.05.

Table 4 Normalization of the Data

Code	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	CI
Weight	0.1656	0.0828	0.0359	0.0359	0.1656	0.0398	0.0442	0.1450	0.1450	0.0933	0.0467	
A1	1.000	0.267	1.000	0.051	1.000	0.145	0.310	0.598	1.000	0.000	0.242	0.654
A2	0.807	0.184	0.863	0.120	0.679	0.103	0.261	0.430	1.000	0.000	0.202	0.529
A3	0.542	0.273	0.296	0.029	0.630	0.148	0.302	0.347	1.000	1.000	0.283	0.550
A4	0.429	0.158	0.431	0.041	0.861	0.105	0.212	0.594	1.000	0.000	0.495	0.512
A5	0.401	0.239	0.471	0.084	0.160	0.284	0.310	0.263	1.000	1.000	0.091	0.438
A6	0.374	0.141	0.349	0.134	0.766	0.105	0.196	0.218	1.000	0.000	0.505	0.431
A7	0.330	0.198	0.333	0.045	0.796	0.123	0.257	0.399	1.000	0.000	0.596	0.464
……	……	……	……	……	……	……	……	……	……	……	……	……
A117	0.002	0.095	0.003	0.024	0.001	0.192	0.065	0.004	0.000	0.000	0.081	0.024
A118	0.002	0.164	0.000	0.007	0.017	0.110	0.249	0.006	0.000	0.000	1.000	0.080
A119	0.001	0.149	0.005	0.102	0.005	0.102	0.273	0.002	0.000	0.000	0.364	0.050
A120	0.001	0.060	0.001	0.002	0.006	0.058	0.237	0.033	0.000	0.000	0.465	0.046
A121	0.000	0.000	0.002	0.166	0.006	0.054	0.000	0.000	0.000	0.000	0.475	0.031
A122	0.000	0.052	0.003	0.040	0.011	0.063	0.147	0.001	0.000	0.000	0.879	0.058
A123	0.000	0.083	0.006	0.011	0.000	0.087	0.200	0.047	0.000	1.000	0.091	0.124

4.5 Results and Discussion

13 samples are randomly selected from the table as the test sample, and the remaining 110 samples are inputted as the training sample of the neural network. After nine iterations the artificial neural network achieved the accuracy requirements and stopped training. After the network training was completed, we input the test group of 13 samples into the network and compared the output with the target output. Predicted results of the artificial neural network are shown in Figure 3.

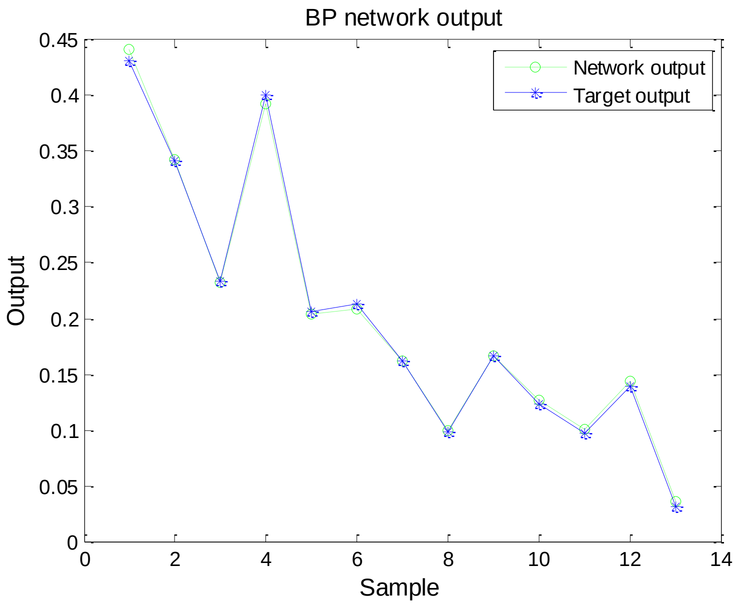

Figure 3 BP network output

The running error summary is shown in Table 5. The maximum absolute error is 0.003, which is less than 0.007, and the maximum relative error is 0.007, which is less than 0.06., These show that the model has good generalization ability (Chen, 2013). The error of the test sample was close to the error of the training sample. Thus the network can be regarded as a good artificial neural network and be effective in competitiveness evaluation.

Table 5 Error of the BP Network

Number	Target Output	Network Output	Absolute Error	Relative Error
A6	0.431	0.426	-0.004830672	-0.011213861
A11	0.342	0.340	-0.002125061	-0.006213939
A17	0.233	0.232	-0.001056841	-0.004544097
A27	0.400	0.395	-0.005053661	-0.012625456
A37	0.206	0.205	-0.000426845	-0.002073997
A47	0.213	0.211	-0.001897174	-0.008920526
A57	0.162	0.162	0.000346077	0.002134696
A75	0.098	0.099	0.001266717	0.01290802
A94	0.166	0.165	-0.000671997	-0.004056566
A100	0.123	0.123	0.00067216	0.00548529
A107	0.097	0.098	0.001138783	0.011778869
A115	0.139	0.142	0.003468047	0.024969556
A121	0.031	0.033	0.001507981	0.04813177
Mean			-0.000589422	0.004289212

5. COMPETITIVENESS EVALUATION OF THE INTERNATIONAL CONTRACTOR

5.1 Clustering Analysis

In order to analyze the competitiveness of Chinese contractors, we divide the Chinese contractors into four levels, according to the evaluation results of competitiveness. The first level consists of contractors that have the strongest competitiveness. These contractors are regarded as the market leader: their competitiveness scores range from 0.3 to 0.6 and the average competitiveness score was 0.404 points. The competitiveness of the second level contractors slightly weaker and they are regarded as the market challenger: their competitiveness scores range from 0.2 to 0.3, and the average competitiveness score was 0.23 points. The third level consists of contractors that are part of the market chaser, who has a large growth space, and their competitiveness scores range from 0.1 to 0.2, and the average competitiveness score was 0.153. The competitiveness of the fourth level is weak. The competitiveness scores fall below 0.1, and the average competitiveness score was 0.089. The hierarchy of the results is shown in Table 6.

Table 6 Levels of Chinese contractors

Level	Amount	Company	Competitiveness score	Mean score
First Level	4	China Communications Construction Group Ltd., Beijing, China China Railway Group Ltd., Beijing, China China State Construction Eng'g Corp., Beijing, China China Railway Construction Corp. Ltd., Beijing, China	> 0.3	0.404
Second Level	5	Sinohydro Group Ltd., Beijing, China China Civil Engineering Constr. Corp., Beijing, China China National Machinery Industry Corp., Beijing, China CITIC Construction Co. Ltd., Beijing, China China Metallurgical Group Corp., Beijing, China	0.2~0.3	0.230
Third Level	13	CGC Overseas Construction Group Co. Ltd., Beijing, China Shanghai Construction Group, Shanghai, China China Gezhouba Group Co. Ltd., Wuhan City, Hubei, China Qingjian Group Co. Ltd., Qingdao, Shandong, China China Int'l Water & Electric Corp. (CWE), Beijing, China China Henan Int'l Cooperation Group Co. Ltd., Zhengzhou, China China General Technology (Group) Holding Ltd., Beijing, China China Geo-Engineering Corp., Beijing, China Zhongmei Engineering Group Ltd., Nanchang City, Jiangxi, China Beijing Construction Eng'g Group Co. Ltd., Beijing, China China Yunan Construction Eng'g Group Co. Ltd., Kunming, China China Dalian Int'l Eco. & Techn. Cooperation Grp., Dalian, China China Jiangsu Int'l Econ. And Technical Coop., Nanjing, China	0.1~0.2	0.153
Fourth Level	4	China Jiangxi Corp. For Int'l Eco. & Tech. Coop., Nanchang, China China Wu Yi Co. Ltd., Fuzhou, Fujian, China Anhui Construction Engineering Group Co. Ltd., Hefei, China Weihai International Eco. & Tech. Coop. Co. Ltd., Weihai, China	< 0.1	0.089

According to the level division and the competitiveness evaluation results, we summarize our findings as follows: in general, in the field of international transportation market, the Chinese contractors have already had certain competitiveness. Of the 55 Chinese contractors from the ENR250 ranking, 26 are involved in transportation engineering projects, including the China Communications Construction Co., LTD., China Railway Group Co., LTD., China National Construction Corporation and China Railway Construction Co., LTD. These four Chinese contractors already belong to the first tier as the strongest competitive companies in the area of transportation, but most Chinese contractors still belong to the third level of the competitiveness as market chasers.

5.2 Case Analysis

In the spring of 2011, China Railway Construction Co., LTD. (CRCC) submitted the intent letter for the construction of high-speed rail in California, so this article chooses CRCC as the research object of case analysis. In the meantime, Bechtel from the U. S. has rich experience in transportation construction, including constructing a total of 6200 miles railway and 35 sets of inter-city rapid transit system in the past. This article uses Bechtel to compare with China Railway Construction to determine the competitive strengths and weaknesses of CRCC in all aspects. As the competitive environment is hard to change and enterprise competence and enterprise resources are prone to change through the various operations of enterprises, this article only analyzes enterprise ability and resources and ignores the competitive environment.

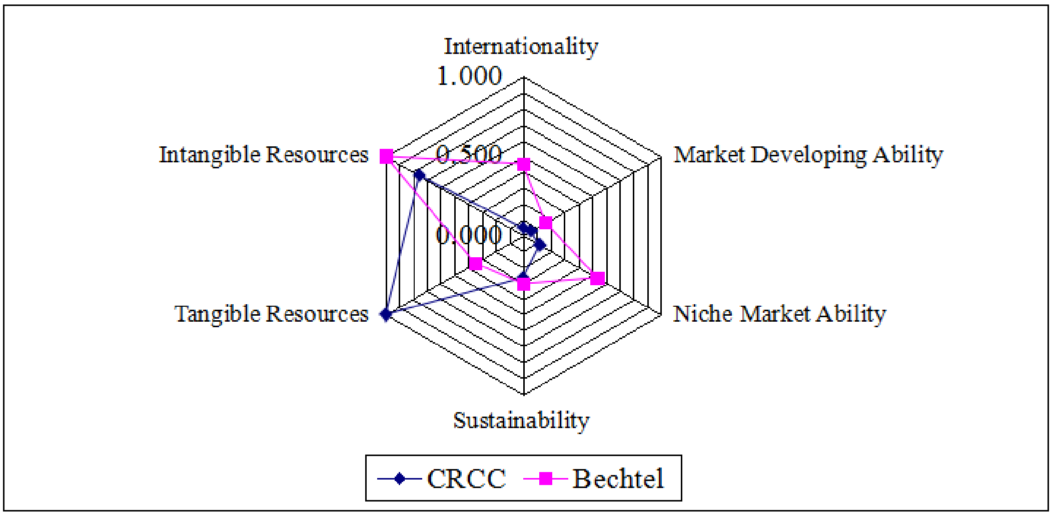

Figure 4 Comparisons between CRCC and Bechtel

The static comparison chart between China Railway Construction and Bechtel from the United States is shown in Figure 4. The competitiveness index score of CRCC was 0.334 in 2013, indicating that CRCC belongs to the first level of the strongest competitive contractors. However, its score is far less than the 0.545 that Bechtel got. In terms of the physical resources, CRCC is stronger than Bechtel. As for market development ability and the ability of sustainable both were almost the same. There is a slight difference in their intangible resources. Yet, CRCC is far weaker than Bechtel in the ability of internationalization -. CRCC is stronger in the tangible resources and ability of sustainable development mainly because CRCC has a large domestic market share in China. Overall, the Chinese contractors are still weak in internationalization and niche market ability. There are still certain gaps compared to the top international rivals.

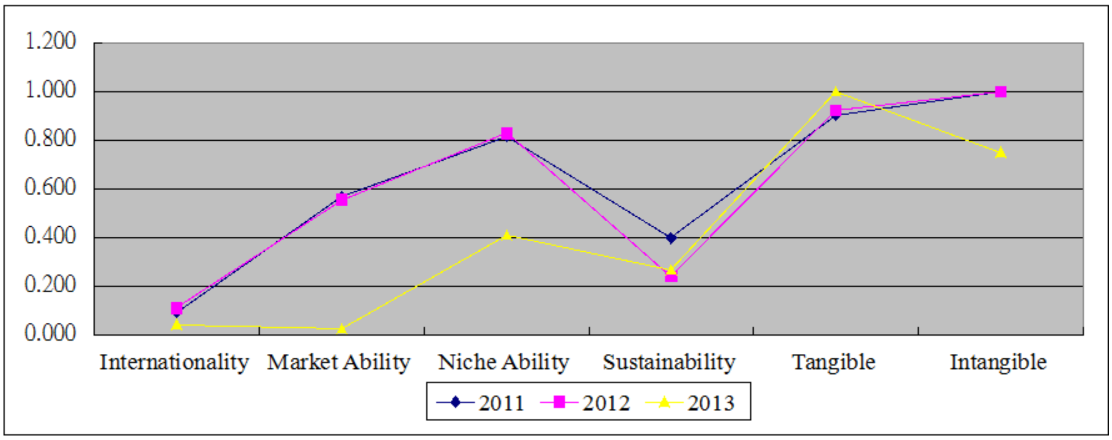

Figure 5 Competitive dynamic monitoring of CRCC

The competitive dynamic monitoring results of CRCC in 2011, 2012 and 2013 are shown in Figure 5. In general, the performance of CRCC was nearly the same in 2011 and 2011, but the 2013 performance has fell: the competitiveness of 2011 and 2012 were 0.5 points, but it fell to 0.334 in 2013, and correspondingly the ENR rank fell to 53 from 30. Causes of the drop include a decrease in the international market turnover, especially the total of the new contracts reduced to a record low in the six years, with a total of less than $5 billion. However, the Chinese domestic market share growth remained very big, so it supported the ability of sustainable development as well as the tangible resources; the results were flat for the first two years. Meanwhile, marketing, transportation market segment and intangible resources index scores all decreased. It is important to note that CRCC focused on traffic construction in 2011 and its housing construction accounted only 10%. But in 2013, CRCC not only raised the proportion of housing construction but also involved in the energy and water conservancy project; its percentage on transportation project fell to 69% in 2013 from 86% in 2011.

6. CONCLUSION

This paper constructs the contractor multi-index evaluation system, using the ENR reports as data source and calculates the weight of each index by the AHP method. It also constructs an artificial neural network and uses the simulated data to evaluate the competitiveness of the contractors through the BP algorithm at the same time. The evaluation model of the artificial neural network constructed by this paper can accurately identify the nonlinear relation between input data and output data of the sample. The neural network model has high prediction precision and good applicability according to the evaluation results of the test group. The model can be used to predict and evaluate the competitiveness of the international contractors and to compare the gap between the Chinese contractors and the international top contractors. In the field of international transportation market, we have already had some companies among the first level of the market leaders, such as China Communications Construction co., LTD., China Railway Group co., LTD., China National Construction Corporation, China Railway Construction Corporation and so on. But the vast majority of Chinese contractors are still playing as the third level chaser in the market. They need to further improve the various elements of competitiveness. Take the leading Chinese contractor

CRCC as an example. The company's success depends solely on its domestic market, but the company is still far behind the top international contractors when other competitiveness indicators are taken into consideration. Its internationalization, market development ability and market segment controlling ability need to be further strengthened.

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