Identify International Market Competition Intensity Based on Social Network Analysis

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Abstract. With the deep development of global economic integration, more and more engineering contractors are actively participating in the international engineering market. In this increasingly active, competitive and complex international engineering market, the intensity of market competition has become an important factor for international engineering contractors in accurately selecting overseas target markets. Although competition in international markets is a widely studied topic, current research on this aspect of the intensity of competition in international markets is not sufficiently advanced. This paper takes the data related to the international market selection of the world's largest 250 international engineering contractors in six different industries, such as transportation, water supply, power, manufacturing, industrial/petroleum, and general building, published by Engineering News Record in 2020, and adopts social network analysis to analyze the intensity of market competition through centrality index as a way to help international engineering contractors to better identify the target market when entering the international market.

Keywords: international engineering · contractors · social network analysis · market competition

1 Introduction

Since entering the new century, more and more engineering contractors have chosen to enter the international market. Statistics from Engineering News Record show a steady growth in global engineering market revenues over the past three years, with the total international business of the top 250 global international engineering contractors having reached $473.07 billion in 2019 and competition in the international market becoming increasingly fierce [10]. Based on statistics, contractors predict that the number of engineering contractors entering international markets and the total amount of international business will continue to trend upward in the future. However, compared to domestic construction markets, foreign markets involve all the uncertainties arising from domestic construction projects as well as the more numerous and complex risks inherent in international transactions. For example, international contractors often face political and economic uncertainties in overseas markets and are exposed to more complex, diverse

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and uncontrollable political, economic and cultural risks [8]. Therefore, facing the high risk and fierce competition in the international engineering market, international contractors must make good market entry decisions to enter the international engineering market, and determining the appropriate market entry may be a key factor affecting success or failure.

The problem of international market entry decisions is rooted in the fact that the globalization of the world economy creates opportunities for companies to internationalize while also impacting on their survival and development space. Foreign markets involve these risks that are not well known to firms in domestic markets, so the study of this issue is central to our understanding of firm internationalization [4, 11]. For example, when a firm lacks confidence in its ability to estimate and predict costs, demand, competition, or environmental conditions in various markets, it can minimize uncertainty in its selection decisions by choosing the market in which it has the best information, and when that factor is reduced, the degree of risk in the firm's investment behavior is subsequently reduced. Therefore, in the context of global economic integration, the need to think strategically about how to effectively and accurately enter the international market is a key decision for companies to enter the international market [2].

Based on the risks often faced in international markets, contractors must consider a variety of influencing factors when choosing to enter international markets, some scholars, such as Sauvant, argue that influencing factors such as the level of competition in the market need to be considered [12]. The level of competition refers to the intensity of competition in the local market. According to the literature review, there are many studies on the level of competition in international markets in the academic community. For example, Zhen Yu Zhao et al. proposed to use market concentration and market share indicators for market competition level analysis [17, 18]. Korkmaz et al. explored the concept of positioning and continuity of their competitive model and scope of competition in the international market, using the example of construction companies in the United States and Turkey, and identified the factors of competitive advantage of each country in the international construction market [7]. Patrick et al. showed that the higher the level of competition in a market, the smaller the market share of the firm will be. The more competitive the market is, the lower the marginal profit a firm will obtain in that market. On the contrary, the less competitive the market is, the more profitable that market will be [9]. Therefore, when expanding into international markets, firms need to consider their own competitiveness and the level of competition in the target market, and avoid entering countries with high competition [1].

However, existing studies have focused on the level of competition in a particular industry or market alone, without linking the two so the study is refined to a market under a specific sector. This paper links the two, industry and market, and obtains the intensity of competition in different markets under each industry through data analysis based on social networks, so that international contractors have more intuitive data to compare when choosing a market to enter.

2 Research Data and Methodology

2.1 Research Data

Engineering News Record is the most authoritative academic magazine in the global engineering and construction field. Its annual report on the world's largest 250 engineering contractors (225 in 2011 and before, 250 thereafter) is one of the industry's most recognized authorities for evaluating contractor competitiveness and gaining insight into international contracting market trends [5]. It provides news, analysis, commentary, and data on the engineering and construction industry to help engineering and construction professionals work more effectively.

This paper focuses first on the data related to the top 250 international contractors in the world in the six sectors of transportation, water supply, power, manufacturing, industrial/petroleum, and general building, published by ENR in 2020. It means that the adjacency matrix is listed according to all the contractors included in each country, and the presence is recorded as 1, while the opposite is recorded as 0.

Secondly, the adjacency matrix is divided into six adjacency matrices according to whether the contractors have turnover in different industries, i.e., when counting a certain industry, contractors without turnover under that industry are removed.

Finally, ENR divided the countries into eight regions: Asia/Australia, North America, North Africa, Caribbean Island, Asia, Europe, Middle East, and Latin America. The above six adjacency matrices are simplified according to this regional classification into adjacency matrices under different regions in different industries and 48 adjacency matrices were obtained as the final study data.

2.2 Methodology

Social network analysis is an influential area of research in mainstream sociology abroad, and at this stage it is widely used as a research paradigm in various disciplines [14]. With the rapid development of modern science and information technology, social network services have emerged in large numbers, bringing convenience to our lives while generating more and more detailed data, and these generated data are a true reflection of social activities and contain detailed information on all aspects of social life. By analyzing the generated data using mathematical methods such as graph theory, this analysis method makes it possible to study the relationships between a large number of individuals in order to find the information inherent beneath the surface of the network system.

Engineering News Ranks annually based on the project contracting revenue realized by contractors in overseas markets. At the same time, the ranking of the world's top 250 contractors based on the total global contracting revenue to measure the contractor's position in the international market [13]. Thus, when contractors choose to enter international markets, the published statistics can provide them with relevant information about the current market. Based on the ranking of revenue values, contractors can get information about the number and position of competitors in the market in different regions and different industries, respectively. However, the results are sketchy and do not link industries to markets, making it difficult to visualize information about the level of competition in each market under different industries.

The research idea of social network analysis provides an interactive perspective and analyzes the problem from an interconnected point of view, which is unique in its scientific and normative nature. Based on this interconnected perspective, this study uses social network analysis tools Ucinet and Netdraw to process and analyze ENR data to analyze the level of competition in each market under different industries, resulting in more granular and specific information.

3 Analysis

3.1 Network Density

Network density refers to the closeness of the relationships among the nodes in a network graph, and its value ranges from (0, 1). The closer the value is to 1, the higher the network density is. The greater the overall network density, the stronger the connection between network node members and the greater the influence of this network on the attitudes and behaviors of the actors in it. For the undirected network constructed in this paper, the overall network density can be calculated by the formula (1):

$$D = \frac{2M}{n(n-1)} \tag{1}$$

where n denotes the number of nodes in the network, and in this paper it denotes the number of countries. $n(n-1)/2$ is the maximum possible relationship between all countries, and M denotes the number of actual relationships included.

The key step in social network analysis is to determine the basic properties of the network, based on which the interaction between nodes can be grasped at a macro level, laying the foundation for further subsequent analysis [6]. In this paper, we use UCINET to convert the 48 adjacency matrices mentioned above into the required data format in turn, and then import them into NetDraw to draw an overall community map, from which the basic characteristics of the network can be derived. Taking the selection of international contractors in the Asia/Australia region (30 countries) under transportation as an example, the overall network diagram is shown in Fig. 1.

In this undirected network, n represents the number of countries in the Asia/Australia regional market where the international engineering contractors in this network are located, then the network density of the network is equal to the number of actual connections within the same industry divided by $(30 \times 29)/2 = 435$. The results that can be derived from the measured characteristics of the basic attributes of the network are shown in Table 1. The network is a network of 764 connections from 30 countries, with an average of 25.47 connections per member and a network density of 0.88, indicating that 88% of the network is already connected. This result indicates that the members within the Asia/Australia region under the transportation industry are highly connected and the competition among members is more intense.

3.2 Centrality

The importance of a node in a social network is measured by centrality, which reflects the position of a node in the whole network and its influence or control over other nodes,

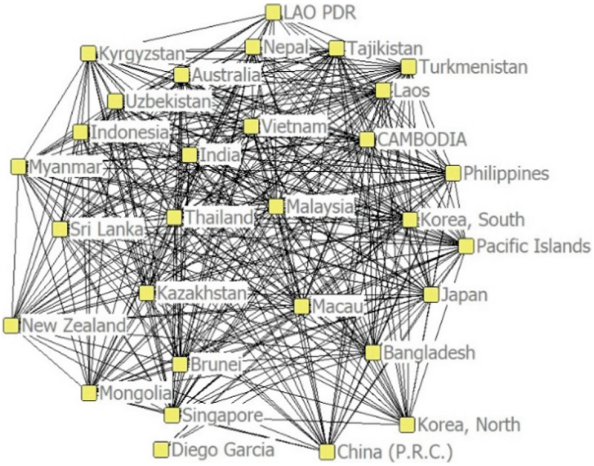

Fig. 1. Overall network diagram

Table 1. Basic properties of the network

No.	Name	Value
1	number of nodes	30
2	number of connections	764
3	density	0.88

and it is a key element of social network analysis research. The higher the centrality, the more important the node is in the network relationship [3]. Commonly used metrics to characterize centrality include: degree centrality, Closeness centrality, and proximity centrality.

This study analyzes the competitive relationship and intensity of competition in the market considering the various country markets in different regions linked to the industry, which provides more detailed information for international contractors when selecting markets to enter. Obviously, the country in the center has a greater information advantage and greater power than the rest of the countries, and its influence on other countries is stronger and more competitive. Therefore, the analysis of centrality in this paper mainly uses degree centrality and closeness centrality as the analysis indicators.

Degree centrality, which is a measure of a node's ability to develop connections with other nodes in the network, can visually reflect the number of other points with which the point is connected [15]. If a point has the largest degree centrality, it is considered to be in a central position and most likely to have the greatest power. Suppose there are N points in an undirected network, then point x is associated with at most the remaining N-1 points, and if the number of points actually associated with point x is C, then the

Table 2. Top 5 Countries by centrality in Asia/Australia under transportation

Country	Degree centrality	Closeness centrality
Philippines	29	29
Indonesia	28	30
Sri Lanka	28	30
India	28	30
Korea, South	28	30

degree centrality of point x can be calculated by the formula (2):

$$Cp(x) = \frac{C}{N-1} \tag{2}$$

Closeness centrality, which portrays a point that is not controlled by other points in its network, is measured by the sum of the shortcut distances between the point and other points in its network [16]. Thus, it can be concluded that the smaller the value of the closeness centrality of a point, the more that point is the core of the network. C_{APi}^{-1} denotes the closeness centrality of a point, and d_{ij} denotes the sum of shortcut distances between point i and point j. Then the closeness centrality of point i can be calculated by the formula (3):

$$C_{API}^{-1} = \sum_{j=1}^{n} d_{ij} \tag{3}$$

The centrality of a country reflects the centrality of that country in this network, and its centrality value specifically quantifies the magnitude of competitive intensity. After importing the adjacency matrix of the transportation industry under the Asia/Australia regional market into the software, the adjacency matrix was transformed into a 30 × 30 multi-valued undirected matrix the country as the center. In order to overcome the influence caused by frequency, the multi-valued undirected matrix is binarized to obtain a 30 × 30 binary undirected matrix, and then the point degree centrality and closeness centrality of each node are calculated, based on the calculation results show that the top 5 countries in centrality ranking can be obtained, and the results are shown in Table 2. The following conclusions can be clearly observed in the table: (1) the ranking results according to the degree centrality and proximity centrality exactly the same; (2) the Philippines country market in the Asia/Australia region under the transportation industry is the most competitive; (3) the other country markets are second only to the Philippines in terms of competitive intensity and are at the same level.

By processing and analyzing the remaining 47 adjacency matrices by the above method, the social network diagrams of the six industries under each of the eight regions can be obtained in turn. Ranking countries by degree centrality identifies markets that are dominant in different industries under different regions. And since only two countries are included under each of the two regions of North America and the Caribbean islands,

Table 3. Top 5 countries by centrality in six regions under three industries

	General Building	Indus. Petroleum	Manufacturing
Latin American	Argentina	Argentina	Ecuador
	Peru	Honduras	Peru
	Brazil	Brazil	Colombia
	Ecuador	Chile	Panama
	Bolivia	Colombia	Nicaragua
Europe	Russia	Belarus	UK
	Spain	Poland	Russia
	Sweden	Russia	France
	Netherlands	Georgia	Netherlands
	Slovakia	Austria	Slovakia
Middle East	Turkey	Jordan	Turkey
	Qatar	Saudi Arabia	Oman
	Oman	Iraq	Saudi Arabia
	Jordan	Turkey	Iraq
	Saudi Arabia	Oman	Iran
Asia/Australia	Philippines	Singapore	India
	Singapore	Nepal	Indonesia
	Sri Lanka	Uzbekistan	Sri Lanka
	India	Myanmar	Myanmar
	Bangladesh	Bangladesh	Singapore
Central/South Africa	Angola	Angola	Angola
	Benin	Benin	Guinea
	Malawi	South Africa	Ghana
	Burkina Faso	Mozambique	Senegal
	Nigeria	Nigeria	SouthAfrica
North Africa	Ethiopia	Ethiopia	Ethiopia
	Algeria	Egypt	Egypt
	Libya	Libya	Algeria
	Egypt	Algeria	Morocco
	Morocco	Morocco	Libya

they are not counted here. The statistical results are shown in Table 3 and Table 4, where each module shows the top five countries, indicating that their competitive intensity is more intense compared to other countries under the corresponding industry and region.

Table 4. Top 5 countries by centrality in six regions under other three industries

	Power	Water Supply	Transportation
Latin American	Colombia	Colombia	Ecuador
	Bolivia	Bolivia	Peru
	Mexico	Mexico	Argentina
	Chile	Chile	Bolivia
	P.Uruguay	Uruguay	Colombia
Europe	Belarus	Spain	Russia
	Russia	Slovakia	Poland
	Spain	Sweden	Georgia
	Georgia	Georgia	FYR M
	Poland	Norway	Sweden
Middle East	Jordan	Qatar	Kuwait
	Saudi Arabia	Oman	Iraq
	Lebanon	Saudi Arabia	Oman
	Kuwait	Kuwait	Turkey
	Iraq	Pakistan	Qatar
Asia/Australia	India	Thailand	Philippines
	Bangladesh	Bangladesh	Indonesia
	Uzbekistan	Sri Lanka	Sri Lanka
	Myanmar	Myanmar	India
	Singapore	Singapore	Korea, South
Central/South Africa	Angola	Angola	Angola
	Benin	Tanzania	Benin
	Malawi	Cameroon	Malawi
	Mozambique	Mozambique	Mozambique
	Nigeria	Senegal	Nigeria
North Africa	Libya	Ethiopia	Libya
	Ethiopia	Libya	Ethiopia
	Morocco	Algeria	Algeria
	Egypt	Egypt	Morocco
	Algeria	Morocco	Egypt

4 Conclusions

Based on the 2020 ENR data, this study analyzes the competitive intensity of different markets by linking two factors, industry and region, through social network analysis to

obtain a competitive relationship map and a competitive intensity ranking table between national markets within each region. The results of this analysis deepen and refine the information provided by the ENR data and provide important support for international engineering contractors to better assess the competitive market situation and choose to enter international markets.

The methodology used in this paper can be extended to a larger number of enterprises in future research, and special analysis of market competition intensity can also be conducted for other country-specific business areas to better grasp the market and competition trends of international engineering contracting business. On the other hand, the limitation of this study is that in order to accurately present the interaction relationship of members, this study treats the number of contacts of all members as if there is a competitive relationship, ignoring the influence of frequency. In this regard, future attempts can also be made to add the consideration of frequency number to construct another idea of membership relationship to make its study more in-depth.

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