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Data-Driven Approaches for Evaluating Countries in the International Construction Market

Kang-Wook Lee[1] and Seung H. Han[2]

Abstract: ***International construction projects are inherently more risky than domestic projects with multi-dimensional uncertainties that require complementary risk management at both the country and project levels. However, despite a growing need for systematic country evaluations, most studies have focused on project-level decisions and lack country-based approaches for firms in the construction industry. Accordingly, this study suggests data-driven approaches for evaluating countries using two quantitative models. The first is a two-stage country segmentation model that not only screens negative countries based on country attractiveness (macro-segmentation) but also identifies promising countries based on the level of past project performance in a given country (micro-segmentation). The second is a multi-criteria country segmentation model that combines a firm's business objective with the country evaluation process based on Kraljic's matrix and fuzzy preference relations (FPR). These models utilize not only secondary data from internationally reputable institutions but also performance data on Korean firms from 1990 to 2014 to evaluate 29 countries. The proposed approaches enable firms to enhance their decision-making capacity for evaluating and selecting countries at the early stage of corporate strategy development.***

Keywords: ***International Construction, Market Uncertainty, Country Evaluation, Data-Driven Approach, Corporate Decision Making***

I. INTRODUCTION

Despite the recent global financial crisis, international engineering and construction firms continue to operate in foreign markets to sustain revenue and profit. However, declining profitability is a critical issue for firms that stems from country- and project-level risks. According to the Engineering News Record (ENR), the average loss ratio for top international contractors began to exceed 10% in 2010 [1], [2]. In particular, many Korean firms have recently suffered from earning shocks due to large deficits in Middle Eastern countries [3]. In this regard, international projects are double-edged swords, encompassing both opportunities and threats that must be systematically analyzed and monitored for business entities.

Han [4] offers a multi-stage sequential decision process model for comprehensive market entry decisions in selecting profitable projects. This model consists of three stages: (1) the country risk evaluation, (2) the candidate project selection, and (3) the project go/no-go decision. Han's [4] model has inspired researchers to further develop models for market entry decisions [5], [6], project selection [7], [8], and risk assessment [9], [10]. However, several limitations have not been addressed. First, the sequential approach for selecting a country and project may not be reasonable for firms in the construction industry. Because the construction industry is a project-based industry (i.e., a made-to-order production system), firms are typically limited by client expenditure, which is strongly influenced by global market uncertainties [11]. Accordingly, selecting a country and project are not separate decisions but are decisions that require a complementary approach to effectively respond to market demands. Second, studies rarely address the topic of country evaluation and selection for international engineering and construction firms. Because preparing to enter or exit a country requires a substantial resource commitment [5], the country evaluation and selection process is a key factor for success in international business activities. However, most firms do not have a formal process for evaluating and selecting countries [12]. Rather, they often make decisions about countries based on (1) the knowledge, experience, and intuition of top management and (2) personal investigations into target countries without a theoretical background. To improve decision-making quality for country evaluation and selection, firms must exploit a systematic framework to support an inter-country analysis. Finally, although numerous valuable secondary data have been provided by internationally reputable institutions (e.g., the World Bank, IHS Global Insight, and Engineering News Records), data-driven approaches using such information in the international construction domain are limited. Compared with primary data, using secondary data provides several advantages: (1) the cost- and time-efficiency for data collection, (2) the breadth of the data available, (3) the data continuity (i.e., easy to update), and (4) the data objectivity and reliability [13]. Thus, if secondary data are properly used with complementary information, the data may provide data-driven strategic guidance for decision makers in international engineering and construction firms.

To address the aforementioned limitations, this paper introduces data-driven approaches for evaluating countries using two quantitative models. The first is a two-stage country segmentation model that not only screens for nega-

[1] Ph.D. Candidate, Dept. of Civil and Environmental Engineering, Yonsei Univ., Seoul, Korea, celebrity3@yonsei.ac.kr (*Corresponding Author)
[2] Professor, Dept. of Civil and Environmental Engineering, Yonsei Univ., Seoul, Korea, shh6018@yonsei.ac.kr

tive countries based on country attractiveness but also identifies promising countries based on the level of past project performance in a given country. The second is a multi-criteria country segmentation model that combines a firm's business objective with a country evaluation process based on Kraljic's matrix and fuzzy preference relations (FPR).

II. Modeling Framework

As shown in Figure 1, this study introduces two models for evaluating countries. First, a two-stage country segmentation model provides a sequential framework based on the theory of international market selection and segmentation. Papadopoulos and Martín [14] defined two terms (market selection and segmentation) as follows. "The term market selection is used when the decision focuses on segmenting the world based on a country-level, while market segmentation is used when a firm attempts to identify markets cross-nationally according to the nature of various industries." By applying this concept to construction, the authors developed an integrative model for both country- and project-level analyses that aids decision makers in identifying and selecting promising countries. Based on Gaston-Breton and Martín [15]'s approach, this model consists of two stages: macro- and micro-segmentation. The first stage addresses the market selection process based on country attractiveness (i.e., a country-level analysis). The second addresses the market segmentation process based on the level of past project performance in a given country (i.e., a project-level analysis). To provide multi-dimensional information on each country, the model utilizes not only secondary data from diverse sources but also performance data on Korean firms from 1990 to 2014 to evaluate 29 countries.

Next, a multi-criteria country segmentation model integrates both macro- and micro-segmentation factors by considering a firm's business objective. Because a firm's strategic choices vary based on external and internal conditions [16], a more strategic approach is required for firms to avoid a "one-size-fits-all" strategy in a given situation. By modifying Kraljic's matrix, the authors propose a comprehensive country evaluation model based on the dimensions and factors drawn from the first model. Additionally, an FPR method is applied to reduce the ambiguity and uncertainty of human judgment as well as to provide a unique solution tailored to the needs of individual firms.

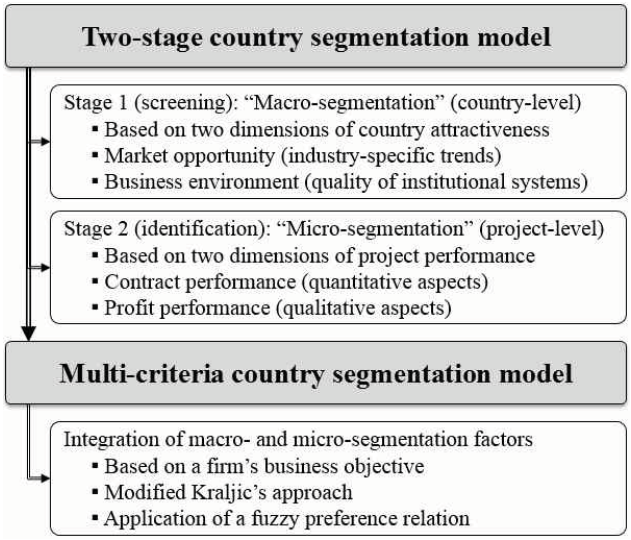

FIGURE I
Two Models for Country Evaluation

III. Two-Stage Country Segmentation Model

A. Variables for Country Segmentation

To identify country segmentation variables, this study investigated existing approaches in the international marketing and construction management fields. Although researchers have suggested different variables based on research objectives, the concept of country attractiveness is most widely used to distinguish various countries. Typically, country attractiveness is a broad and multi-dimensional concept that incorporates political, economic, and socio-cultural aspects of individual countries [15]. In this regard, two dimensions of country attractiveness are considered for macro-segmentation: market opportunity and business environment. Market opportunity considers industry-specific trends (the market size, market growth, market volatility, and competitive strength of the construction industry) [5], [17], [18], whereas business environment reflects the quality of the institutional systems (the political, legal, and socio-cultural characteristics of a given country) [16], [19], [20].

Similarly, for micro-segmentation, two dimensions of project performance are considered: contract and profit performance. Contract performance focuses on the quantitative aspects of international contracts (the number of contracts, contract volume, and bid-hit ratio), whereas profit performance considers the qualitative aspects of project profitability (the profit margin, profit uncertainty, and possibility of profit loss).

TABLE I
Variables for Country Segmentation

(a) Variables for macro-segmentation

Category	Variable
Market opportunity	[V1] Construction market size
	[V2] Construction market growth rate
	[V3] Construction market volatility
	[V4] Intensity of competition
Business environment	[V5] Quality of national governance
	[V6] Ease of doing business
	[V7] Openness to international firms
	[V8] Construction risk

(b) Variables for micro-segmentation

Category	Variable
Contract performance	[V9] Cumulative number of contracts
	[V10] Cumulative contract amount
	[V11] Bid-hit ratio
Profit performance	[V12] Average profit margin
	[V13] Profit uncertainty
	[V14] Possibility of profit loss

In short, as shown in Table 1, this study utilized eight variables for macro-segmentation and six variables for micro-segmentation. The individual variables are directly linked to objective and evidence-based datasets to develop quantitative models.

B. Data Collection

For a quantitative analysis on a country-by-country basis, the authors collected not only secondary data at the country-level but also performance data at the project level. Construction market- and country-specific data are provided by internationally reputable institutions, such as the World Bank, IHS Global Insight, and Engineering News Records. Additionally, project performance data on Korean firms were obtained through the International Contractors Association of Korea. The data reflect the recent trends for each country in the 2010s. In particular, this study utilizes project performance data on Korean firms from 1990 to 2014. Based on the available data for each country, 29 countries were considered in an inter-country comparison.

C. Statistical Analysis Results

In this study, factor analyses and cluster analyses were used as the main statistical analysis techniques. First, using factor analysis, the authors examined the dimensionality of both macro- and micro-segmentation factors based on a principal component analysis and varimax rotation. As shown in Table 2, three factors were extracted from the macro-segmentation variables (F1: market environment, F2: market uncertainty, and F3: market potential), and two factors were extracted for micro-segmentation (F4: possibility of project failure and F5: project experience). The extracted factors for each stage are mutually exclusive and explain more than 70% of the total variances (78.9% for macro- and 70.5% for micro-segmentation).

TABLE II
RESULT OF FACTOR ANALYSIS
(a) Extracted factors from macro-segmentation variables

Extracted factor	Initial variable	Factor loading	Variance extracted
[F1] Market environment	V5	0.954	0.436
	V8	-0.904	
	V6	0.884	
	V7	0.773	
[F2] Market uncertainty	V3	0.884	0.202
	V4	-0.802	
[F3] Market potential	V1	0.865	0.151
	V2	0.617	

(b) Extracted factors from micro-segmentation variables

Extracted factor	Initial variable	Factor loading	Variance extracted
[F4] Possibility of project failure	V14	0.846	0.390
	V12	-0.822	
	V11	-0.730	
[F5] Project experience	V9	0.891	0.315
	V10	0.753	
	V13	0.684	

Subsequently, a K-mean cluster analysis was performed to classify 29 countries using the factor scores obtained. Figure 2 shows a macro-segmentation example, in which three clusters were created that represent higher and lower levels of attractiveness based on the market environment (F1) and market uncertainty (F2). The first cluster consists of eleven countries with business-friendly environments and moderate market uncertainty scores: Germany, Hong Kong, Hungary, Japan, Mexico, Poland, Singapore, Slovakia, Taiwan, the United Kingdom and the United States. The second cluster consists of nine countries that are positive for market uncertainty but negative for market environment: Bangladesh, China, Indonesia, Malaysia, Philippines, Saudi Arabia, Thailand, the United Arab Emirates and Vietnam. Finally, the third cluster includes nine countries that are less attractive based on both dimensions: Brazil, Egypt, India, Iran, Jordan, Kuwait, Pakistan, Romania, and Russia. Because the main purpose of the first stage (i.e., macro-segmentation) is to screen negative countries, decision makers can lower the priorities of less attractive countries in their international business over the long term.

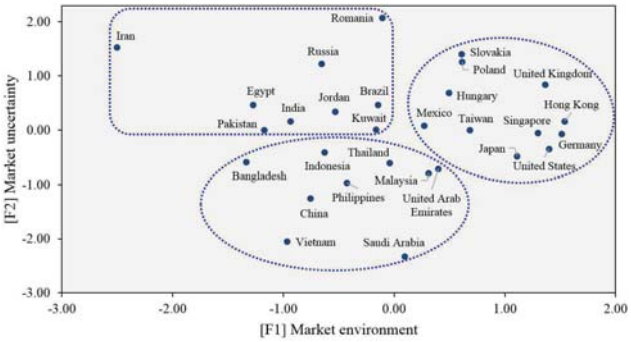

FIGURE II
MACRO-SEGMENTATION: F1 AND F2

After the country-screening process, decision makers further identify promising countries based on the level of past project performance on a country-by-country basis (i.e., micro-segmentation). As an example, Figure 3 shows information on past project performance for the second cluster countries in Figure 2. Statistical information on micro-segmentation factors (F4 and F5) can support decision makers in identifying the most promising countries and establish more feasible market entry strategies for selected countries.

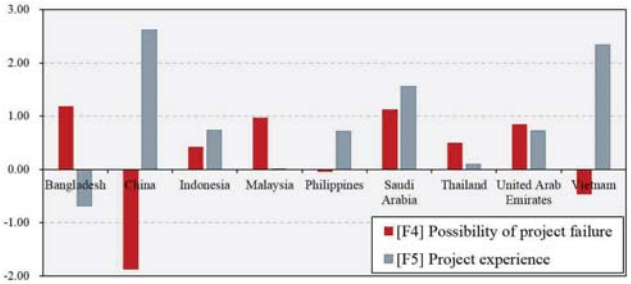

FIGURE III
PROJECT PERFORMANCE OF THE SECOND CLUSTER COUNTRIES

IV. Multi-Criteria Country Segmentation Model

A. Modified Kraljic's Approach

Although the first model provides useful input for reviewing multi-dimensional aspects of a country, each firm has a different business objective in a given situation (e.g., revenue- or profit-seeking objective). To incorporate a firm's business objective into the decision-making process, a more strategic approach is required. Kraljic [21] introduced a comprehensive model to classify a firm's purchased items using a 2 × 2 matrix. Based on two dimensions (profit impact and supply risk), each item may be grouped into one of four categories: (1) non-critical items (supply risk: low; profit impact: low); (2) leverage items (supply risk: low; profit impact: high); (3) bottleneck items (supply risk: high; profit impact: low); and (4) strategic items (supply risk: high; profit impact: high). Kraljic's matrix provides a useful framework for multi-criteria segmentation analyses due to its simplicity, logic, and inclusiveness [22]. Accordingly, this study uses Kraljic's matrix as well as the dimensions and factors from the first model.

Additionally, this study applies fuzzy preference relations (FPR) to reduce the ambiguity and uncertainty of human judgment. Recently, FPR was recognized as a practical method for addressing priority-ranking problems [6], [22]. Compared with traditional approaches represented by the fuzzy analytic hierarchy process (AHP), this method offers two strengths: (1) FPR yields consistent results in priority ranking, and (2) FPR requires fewer pairwise comparisons [22]. An FPR-based multi-criteria country segmentation model was developed in this study. By combining both quantitative (factor scores obtained through factor analyses) and qualitative (fuzzy pairwise comparison of the evaluation criteria) information, the results from this model define a country as one of four types.

B. Illustrative Example

To obtain the relative weights of the evaluation criteria, a pairwise comparison matrix was first established. According to Table 3, a linguistic variable is quantified based on triangular fuzzy numbers; it is only required to fill in n – 1 (n: number of evaluation criteria) cells in the pairwise comparison matrix (see Table 4). The remaining cells are calculated based on reciprocity and consistency [22], [23]. After linear transformation, normalization, and defuzzification processes, the relative weights of the evaluation criteria are determined. Detailed technical information can be found in Rezaei and Ortt [22] as well as Wang and Chen [23].

TABLE III
Fuzzy Linguistic Assessment Variables

Linguistic variables	Triangular fuzzy numbers
Extreme weak importance (EWI)	(0.0, 0.0, 0.1)
Very weak importance (VWI)	(0.0, 0.1, 0.3)
Weak importance (WI)	(0.1, 0.3, 0.5)
Equal importance (EI)	(0.3, 0.5, 0.7)
Strong importance (SI)	(0.5, 0.7, 0.9)
Very strong importance (VSI)	(0.7, 0.9, 1.0)
Extreme strong importance (ESI)	(0.9, 1.0, 1.0)

TABLE IV
Fuzzy Pairwise Comparison of Evaluation Criteria

	F1	F2	F3	F4	F5
F1		EI	×	×	×
F2			VSI	×	×
F3				EWI	×
F4					SI
F5					

If a firm has a profit-seeking objective for its international business, a fuzzy pairwise comparison can be established as shown in Table 4: F1 has equal importance (EI) as F2; F2 has very strong importance (VSI) compared with F3; F3 has extreme weak importance (EWI) compared with F4; and F4 has strong importance (SI) compared with F5. After computation using the FPR algorithm, the relative weights of the evaluation criteria were determined as follows: 0.222 for F1, 0.216 for F2, 0.117 for F3, 0.245 for F4, and 0.201 for F5. The weighted scores for the two dimensions (the level of country attractiveness and project performance) for each country are then finalized (see Figure 4). The model classifies 29 countries into four segments using a 2 × 2 matrix. As shown in Figure 4, eight countries are assigned to Type 1 (low attractiveness and low performance); six countries are assigned to Type 2 (low attractiveness and high performance); four countries are assigned to Type 3 (high attractiveness and low performance); and eleven countries are assigned to Type 4 (high attractiveness and high performance). This implies that eleven countries compose the most promising group (Type 4) from the perspective of the profit-seeking firm described above. Eighteen countries lack attractiveness (Type 3), performance (Type 2) or both (Type 1). Based on the country types and scores, decision makers may not only prioritize countries but also diagnose the status of their country portfolio based on their business objectives.

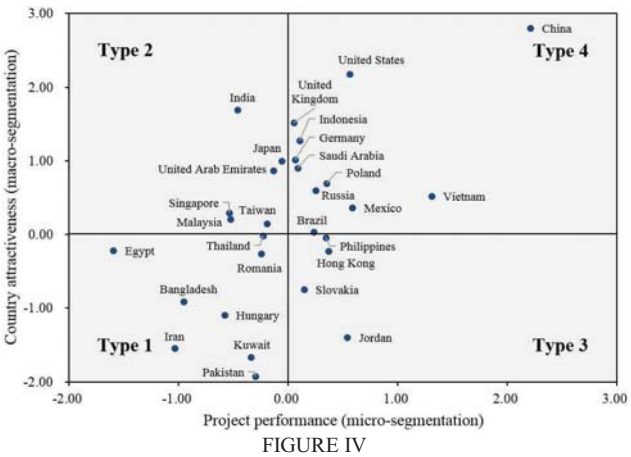

FIGURE IV
Multi-Criteria Country Segmentation

V. Discussions and Conclusions

This paper introduces data-driven approaches for country evaluation using two quantitative models. The first model provides a sequential framework for reviewing multi-dimensional aspects of candidate countries based on extensive datasets. In contrast, the second model incorporates a firm's business objective into the data-driven model to avoid a "one-size-fits-all" strategy in a given situation. In rapidly changing and highly competitive international construction environments, evaluating and selecting countries is crucial for business entities. The authors expect that the proposed approaches will aid in enhancing a firm's decision-making capability during the country evaluation and selection process. Data-driven strategic guidance could be further beneficial for decision makers when they address country-related issues, such as diversification strategy and portfolio management, at the early stage of corporate strategy development.

Despite its contributions, this study includes a few limitations. First, due to the lack of project-level data, this study only used project performance data on Korean firms, which may not be adequate for firms in other countries. Additionally, the second model requires a validation process to determine whether the model properly reflects a firm's business objective. To this end, additional research, such as case studies and interviews, should be conducted.

Acknowledgements

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