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# A Decision Support System for Small & Medium Construction Companies (SMCCs) at the early stages of international projects

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***Abstract:** Despite the significant increase of Korean contractors in the international construction market, many SMCCs (Small & Medium Construction Companies) have suffered in the global financial crisis, and some of them have been kicked out of the international market after experiencing huge losses on projects. SMCCs face obstacles in the international market, such as an insufficient ability to gather information and inappropriate management of associated risks, which lead to difficulties in establishing effective business strategies. In other words, making immature decisions without an effective business strategy may cause not only the failure of one project but also the bankruptcy of the SMCC. To overcome this, the research presented herein aims to propose a decision support system for SMCCs, which would screen projects and make a go/no-go decision at the early stages of international projects. The proposed system comprises a double axis: (1) a profit prediction model, which evaluates 10 project properties using an objective methodology based on a historical project performance database and roughly suggests expected profit rate, and (2) a feasibility assessment model, which evaluates 17 project environment factors in a subjective and quantitative methodology based on experience and supervision. Finally, a web-based system is established to enhance the practical usability, which is expected to be a good reference for inexperienced SMCCs to make proper decisions and establish effective business strategies.*

***Keywords:** SMCC, Decision Support System, Risk Assessment, Profit Prediction, Early Decision*

## I. INTRODUCTION

### *A. Introduction*

The prevalence of Korean contractors has significantly increased in the international construction market since the mid-2000s. Thirteen Korean firms are placed in the ENR top 250, 8 of which are ranked in the ENR top 50 as of 2014 (ENR, 2014). However, there is another side to this growth, as there are concerns about polarization; the proportion of projects concentrated among large companies rose from 77.6% in 2006–2010 to 87.4% in 2011–2015 (Table 1), and the deficit rate of international projects carried out by SMCCs is double that of large companies (ICAK, 2014). Many SMCCs suffered due to the financial crisis, and some of them were kicked out of the international market after experiencing huge losses on projects.

According to past research, SMCCs face obstacles in the international market, such as an insufficient level of ability to gather information and inappropriate management of associated risks, which lead to difficulties in establishing effective business strategies. Nevertheless, most decisions of SMCCs depend on the owners' intuition and experts' knowledge. Thus, decision-making regarding international projects involves further uncertainty, and these circumstances influence the financial variation of projects. In other words, immature decisions without an effective business strategy may cause not only the failure of one project but also the bankruptcy of the SMCC.

To solve these issues, this research aims to develop a decision support system for SMCCs in which projects are screened and go/no-go decisions are made at the early stages of international projects.

For the decision support system, the necessary conditions are as follows. First, it must be specific to the SMCC and reflect the factors from a subcontractor perspective. Second, it must be used at the early stages of projects to make go/no-go decisions. Third, it must be able to predict the profit rate and evaluate the feasibility based on limited information available at early stages. Fourth, it must establish a system to include experts' experience for objective and quantitative analysis. To support the decision-making process, the authors propose the project feasibility assessment method, which comprises a double axis: (1) a profit prediction model and (2) a feasibility assessment model.

### *B. Literature Review*

Previous research related to a decision support model for international projects can be divided into three categories. One contains the research that analyzes the risks regarding international project performance. These studies provide the basis of international project decisions (Han and Diekmann, 2001; Han et al, 2003; Suat Gunhan et al, 2005; Han et al, 2005; Kim et al, 2009). The second contains those that quantify the relationship between project performance and project influence factors and suggest a prediction model for project performance (Han and Kim, 2006; Jung, 2007; Han et al, 2007). The third includes decision support models from various perspectives such as enterprise capability, real options,

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and prediction models for exceeding cost (Amani, Dikmen, 2009; Kim et al, 2009; Kim et al, 2013; Yildiz et al, 2014; Jang et al, 2014). In addition, with a focus on SMCCs, Jung (2010) analyzed the 5 different strategies of international project participation for SMCCs and validated 13 research hypotheses. This research demonstrates how, from the perspective of SMCCs, subcontracting practices involve many difficulties, for which statistically insignificant results have been shown. Despite the various types of strategies used by construction companies, this research focuses on the subcontracting practices of SMCCs that are primarily based on common strategies used in the company's home country. Through the results of this research, SMCCs can gain insight into strategies for improving their advancement in international construction. Lee (2015) created a framework that considers the risks to which subcontractors are exposed during a construction project to create a win-win strategy with the general contractor. By deriving risk factors that affect the project performance from the subcontractor's perspective, an effective project management strategy can be suggested.

From the literature review, it is evident that there are many studies on deriving project influencing factors and making decisions on international projects. However, these studies mainly focus on the general contractor's perspective. In addition, there have been few studies on the properties of SMCCs and the development of profit prediction models or decision support systems for practical use.

## II. MODEL DESCRIPTION

### *A. Model Overview*


Figure 1. Decision Support System Framework

To supplement the limitations of previous research, as previously mentioned, this research develops a decision support system that consists of two models: (1) a profit prediction model and (2) a feasibility assessment model. In the profit prediction process, the model evaluates 10 project properties as objectives based on a historical project performance database. In the feasibility assessment process, the user subjectively evaluates 17 project environment factors based on experience and supervision. Both the project property and project environment include factors that focus on the perspective of SMCCs and can be used in the early stages of projects. A detailed explanation of each model is described in the following sections.

By using this model, an SMCC can select projects that are appropriate for its capability and make objective go/no-go decisions.

### *B. Profit Prediction Model*

The profit prediction model provides a rough expected profit rate (estimation contingency: 30–50%; CalTrans, 2007)) based on similar cases using limited project information at the early stages.

The process of developing the profit prediction model consists of 4 steps. First, 8,367 international construction project cases (ICAK, 2015) are analyzed to derive factors that affect a project's profit. Each project case has 50 types of information, 25 of which are unavailable at the early stages of a project. Thus, 25 factors are derived from case information. Finally, from expert interviews, 10 factors (region, country, business category, type of contract, source of financing, contract amount, project duration, and business environment) are determined as key influencing factors.

Table 1. Project Properties

| **Project Properties** | |
|---|---|
| Region | Source of Financing |
| Country | Contract Amount |
| Work Category | Project Duration |
| Type of Contract | Business Environment |
| Bid Process | Exchange Rate |

Second, the weight of each key influencing factor is determined by multiple regression analysis and inductive reasoning. The weights of factors based on characteristics are set to be uniform because they are used as judgement criteria for conformity. The weights of numeric factors are determined using coefficients of multiple regression.

Third, the profit rate of 668 similar (construction,

Figure 2. Example of the Profit Prediction Model

| | Character Type | | | | | | Numeral Type | | | | Output |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.201 | 0.485 | 0.099 | 0.214 | |
| Project Property | Region | Country | Work Categoty | Bid Process | Type of Contract | Source of Finance | Contract Amount | Project Duration | Exchange Rate | DBI | |
| Case Input | Asia | Malaysia | Civil | Open | Fixed | Public | 201 | 239 | 844.2 | 81.84 | |

subcontract) project cases is divided into 5 ratings (Very bad, Bad, Normal, Good, Very good) according to their distribution. To diminish statistical error, cases located outside the 95% confidence interval are eliminated.

Fourth, the profit prediction model using the CBR technique is developed. The model calculates the similarity score of each case and determines that the cases with scores above 120 (200) are similar. Finally, it achieves a prediction of the profit rating in which the most similar cases are placed.

Figure 2 shows the Excel-based prototype of the developed model. If a user inputs the 10 project properties of the target project, the model searches for similar cases and outputs their profit distribution. Factors such as DBI (Doing Business Indicator) are automatically inputted from the country information.

Actual project cases are used in the test to validate the model. Among the 120 project cases, the results indicate that there are 50 good cases, 22 normal cases and 48 bad cases. The model identifies only 14 incorrect results, of which 7 were false negatives and 7 were false positives. Considering the limitations regarding project information and difficulties in predicting the profit rate, this is a fairly good result.

*C. Feasibility Assessment Model*

The feasibility assessment model evaluates the project environment by a subjective and quantitative method. To accomplish this, each project is evaluated by 7 criteria in 3 categories (characteristics of owner and host country, project properties, capabilities of company).

The seventeen criteria are derived from a literature review and an analysis of the feasibility assessment method used by domestic/foreign construction companies and public organizations.

Criteria include factors regarding public confidence, such as the OECD level, World Governance Indicator, and Doing Business Indicator, and are focused on SMCC perspectives, such as contractor rationality and the availability of resources. Thus, compared to existing feasibility assessment criteria, the developed model can suggest differentiated and customized feasibility assessment results.

Each criterion is evaluated on a 5-point scale; if the sum of the scores of the 17 criteria is high, the feasibility is considered to be high. The 17 criteria are detailed in Table 2.

Table 2. Feasibility Assessment Criteria

| Category | Criteria |
|---|---|
| Characteristics of owner and host country | Host Country Credit |
| | Maturity of political environment |
| | Business Environment |
| | Owner Rationality |
| | Ability to finance project |
| Project properties | Delivery Method |
| | Propriety of Project Duration |
| | Level of difficulty |
| | Contractor Rationality |
| | Site familiarity |
| | Availability of resources |
| | Followed-up project |
| Capabilities of company | Technical Expertise |
| | Connection with owner |
| | Experience of Host country |
| | Performance of similar project |
| | Average profit of similar project |

The feasibility assessment results are divided into 5 ratings (worst, bad, normal, good, very good) relative to historical data. However, the feasibility assessment criteria and evaluation method in this model should be advanced by future research.

*C. Final Decision*

The final result is expressed in a 5×5 table; each cell is selected from the table according to the risk assessment model, and the profit prediction model includes 3 suggestions (Green: Recommend participation, Amber: More consideration, Red: Abandonment). For example, if the results for both profit prediction and feasibility assessment are good, then the go/no-go decision is Green (recommend participation). Conversely, if the profit result is good but the feasibility assessment result is bad, the decision is amber, which means that participation in this project should be further considered. By using this system, inexperienced SMCCs can obtain a useful reference for international project participation based on the given predicted profit rate and feasibility assessment result at the early stages of a project. Figure 3 shows the developed system that produces the profit prediction and feasibility assessment.

Figure 1. Decision Support System for SMCC

*D. Model Application*

To investigate the applicability of the developed system, a comprehensive survey was conducted. The usability (easiness of system use), suitability (goodness of system structure) and practicality (availability for practical use) of the system were assessed by using a five-point Likert scale. A total of 19 experts with average industry experience of 24.8 years answered the survey questionnaires. The results of the survey are shown in Table 3.

Table 3. Results of Survey

| | **Usability** | **Suitability** | **Practicality** |
|---|---|---|---|
| **score** | 4.26 | 4.11 | 4.26 |

The average scores for usability, suitability, practicality and desired level of satisfaction are 4.26, 4.11, 4.26, and 4.37, respectively. From this survey, the applicability of the developed system is indirectly determined.

## III. CONCLUSION

The proposed decision support system is intended to help SMCCs make go/no-go decisions, including a profit prediction model using 10 project properties based on a historical database and a feasibility assessment model using 17 project environment characteristics. By using this model, SMCCs can select projects that are appropriate for their capability and make objective go/no-go decisions.

The introduced system is part of FIRMS (Fully Integrated Risk Management System) by ICAK (International Contractors Association of Korea) and first became available in April 2015. FIRMS features various models in addition to the introduced model to evaluate and compare capabilities between companies, provide information about interests regarding work and country, and assess risk according to the project phase from the perspectives of SMCCs and subcontractors.

Future research is planned to include a validation of the existing system and the development of models from the perspectives of SMCCs and general contractors as well as an enterprise risk management model.

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