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Profit Forecasting Model for International Projects Using Multiple Regression Analysis and Neural Networks

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Abstract
International projects are inherently exposed to unpredictable and complicated risk scenarios. To minimize the possible losses due to the risks, most of construction firms have their own procedures or primitive methods of screening potential projects nominated. The screening rules are usually based on the engineers' and decision makers' experience and knowledge which are often very subjective and lack of scientific basis. Systematic risk analysis of international projects should entail the processes of defining, analyzing, and controlling of various risk factors. In this paper, a scale-based profit forecasting model for international project is presented. Many successful and unsuccessful international project cases with respect to profitability are collected. Then, scale-based profit forecasting model are developed through a multiple regression analysis and a neural networks. Finally, this paper presents the comparative analysis of these two models, and furthermore provides lessons learned to improve profitability.

Keywords
Risk Management, International Construction, Forecasting Model, Regression Analysis, Neural Networks

1. Introduction

According to ENR(Engineering News Record 1994~2003), 15.1% of the top 225 global contactors are suffering losses in international construction markets. It implies that international construction projects have more uncertanties and higher risks. Experiences on the successful performacne in the domestic projects do not secure successes in international projects. Subsequently, many authors have emphasized the importance of managing risks systematically under the floating environment of international construction markets (Bing and Tiong,1999; Hastak and Shaked, 2000; Han and Diekmann, 2001). Although these researches draw valuable points of international risk management, they cannot sufficiently reveal the apparent interaction between risk factors and project performances, particularly in view of profitability. The main objective of this paper is to develop the scale-based profit forecasting model for international construction projects by analyzing the causal relationships between risk factors (profit-influencing variables) and project profitability. This study applies multiple regression analysis and neural networks for causal analysis and compares these two methodologies as a validation process.

2. Risk factors affecting project profitability

It is important to establish a suitable strategic point of risk management through identifying risk factors which affect the project performance significantly. Because of the importance of risk factors, there has been many researhes on identifying the risk factors (Zhi, 1995; Bing et al., 1999; Wang et al., 2000; Chan et al., 2001). This research draws the criteria of risk classification on the basis of reviewing result of previous studies. As a result of extensive literature reviews, 93 risk factors are drawn into five classes such as: (1) condition of host country and project owner, (2) information on project acquisition and bidding, (3) project characteristics and contractual conditions, (4) characteristics of organization and participants, and (5) contractor's ability and capacity. Although these risk factors include most of the previous literatures concerned about these issues, they have limitations in view of a practical usage. Ensuring the applicability of risk factors, series of focused-group discussions with practical experts on international construction were followed. Additionally, 15 real cases of international projects that exposed to the severe losses were reviewed to find any valuable sources in identifying risk variables. Through the cases reviews and advice of experts to combine duplicate sources and to remove the slight-influencing/trivial factors, we draw a total of 64 profit-influencing variables on overseas construction projects, as shown in Figure 1.

3. Data collection

The structured case survey based on these risk factors were conducted for gathering information of project profit and management level of risk factors. Questionnaire consists of 2 main parts: (1) performances of a project in the sense of profitability, and (2) management level of each factor in achieving profitability. The success level of project (in terms of profit margin) are measured using 7-point Likert scale ('1: Not successful at all' to '7: Exceptionally successful'). The management level of 64 risk factors are measured by 7-point Likert scale ('1: Very bad' to '7: Very good'). The level of management of a factor refers to the extent the factor affects the profitability of international projects. If respondent answer low index, it is likely that this factor is perceived, to some degree, as significant to the bad profits. Data were collected from the Korean overseas construction companies based on their real perfomance and experience on the international construction projects. As a result of the case survey, data from 90 international projects, based on the project-specific information, were collected.

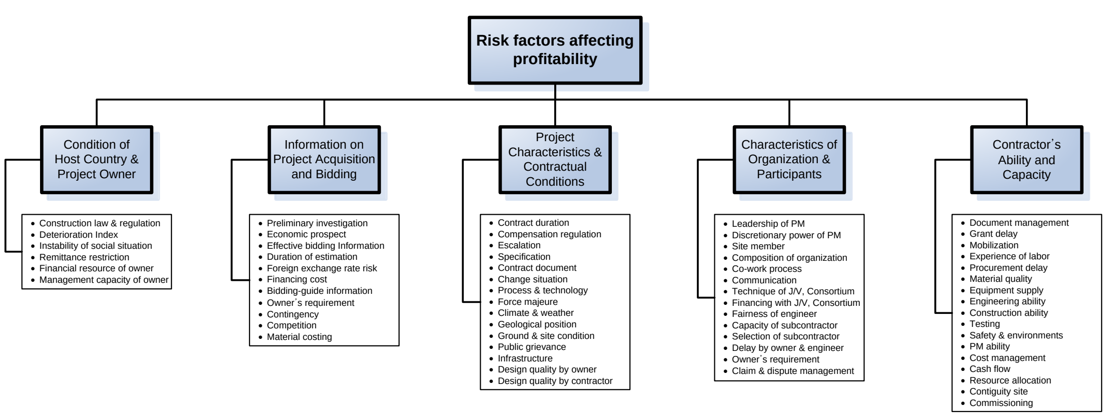

Figure 1: Risk factors (5 classes – 64 factors)

4. Multiple regression analysis

In this study, multiple regression analysis was adopted to analyze causal relationship between project profit and management level of risk factors. As a first step, Factor Analysis was used to compress risk factors to relevant groups that have a high correlation each other. This procedure is often used to reduce the number of variables in a data set. Through the principle component analysis we sorted out the variables which had eigenvalue of above 1. As a result, the 14 group factors were drawn as a valid sub-dimensional representation of the initial sources of 64 risk factors. Total variance in project profitability explained by these group factors is 70.37 %. The results of Factor Analysis were correlated with the project performance to evaluate the relationships between the success level of project and the fourteen underlying dimensions of the group factors. Stepwise regression analysis was performed to test the hypothesis in these relationships. As a result, final regression model was drawn by 8 steps of variable selection process. Table 1 shows the result of the regression analysis.

Table 1: The Result of Multiple regression analysis

a) Model summary

Model	R	R square	Adjusted R square	Std. deviation of presumption	Durbin-Watson
8	**0.743**	**0.552**	**0.508**	**1.308**	**1.805**

Coefficients of multiple regression analysis

Composition (Group Factors)	Unstandardized coefficient		Standardized coefficient	t	Significance
	B	Standard error	beta		
Constant	**4.670**	**0.138**		**33.873**	**0.000**
F10 Quality of estimation	**0.619**	**0.139**	**0.332**	**4.467**	**0.000**
F7 Project information in early stage	**0.527**	**0.139**	**0.283**	**3.800**	**0.000**
F4 Attitude and ability of owner &	**0.506**	**0.139**	**0.271**	**3.647**	**0.000**
F12 Contract condition and management	**0.499**	**0.139**	**0.267**	**3.596**	**0.001**
F2 Project condition – resource delivery, labor skill, etc	**0.477**	**0.139**	**0.256**	**3.440**	**0.001**
Commitment of organization – PM petency, etc	**0.470**	**0.139**	**0.252**	**3.393**	**0.001**
F1 Contractor's ability & experience	**0.402**	**0.139**	**0.216**	**2.899**	**0.005**
F8 Quality of design	**0.379**	**0.139**	**0.203**	**2.734**	**0.008**

The model accounts for 55.2% of the variance indicating a moderate to good association between the independent variables and the dependent variable. As well, eight of fourteen group factors have a significant linear relationship with the success level of project profit. Among these factors, F10 (quality of estimation factor) and F7 (project information factor) have higher impacts on project profit than those of other factors, of which their coefficient values are 0.619 and 0.527, respectively.

5. Profitability Forecasting Model Using Artificial Neural Network

A network built in this paper uses questionnaire answers as network's inputs (mamagement level of risk factors) and it's single output figure (success level of profit). Thus, entering the answers from each project, the weights and biases of each layer in the network can be trained to make the closest target results. Once the weights and biases are trained adequately, and if there is a set of new answers of the probable projects, success level of profit can be enabled (Figure 2). In this paper 90 projects were used to make a network and 15 another projects were used to validate the ANN forecasting. To build a artificial neural network, the number of middle hidden layer, the number of neurons in each layer, transfer function of each neuron, and training function to adjust the weights should be decided in advamce. But if there are hidden layers, the number of layers and neurons does not have large impact on forecasting accuracy (Hargan, 1996). The network in this paper was designed to have three layers and each layer has 5, 2, and 1 neurons, respectively. The transfer function of each neuron in 1st and 3rd layer was log-sigmoid function which generates a value between 0 and 1. On the other hand, middle layer's transfer function was tan-sigmoid function which generate a figure between -1 and 1. Therefore the last result of this network is a single value between 0 and 1, which is the transformed scale of the success level of profit. The answer set of qustionnaires or projects whose response rate is under 90% were excluded from training network because the they can cause unreasonable results. Accordingly, the input layer is made of 76 projects and 59 question answers([59 × 76] matrix) and the target values are the 76 figures of success level([1×76] matrix). Process in the network can be expressed as a calculation of matrices as shown in Figure 3. Back-propagation algorithm is used to train the weights of the neural network, which is a systematic method for training multiple-layer artificial neural networks. Input vectors and the corresponding target vectors are used to train a network until it can approximate a function and to associate input vectors with specific output vectors.

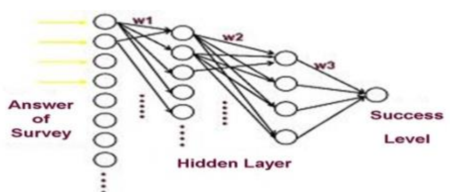

Figure 2: Structure of Neural Network

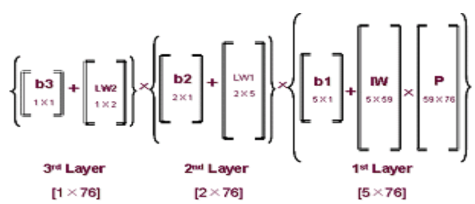

Figure 3: Process of the Neural Network

6. Validation of the models

Although the 90 projects used to build forecasting model have many similarity to the other projects, it is noted that they are just particular samples of a population. Therefore, the models needed to be validated. Toward this end, another 15 projects were selected to validate the models by comparing the output from models to the answered success level of profit. T-test was used to find the differences between previous 90 projects and additional 15 projects. As a result of T-test, the level of significance of two-tailed test is 0.962 in project duration and 0.935 in project costs, respectively, which means that there are few differences between two distributions of project groups. The deviation between output from two models and success levels from the respndents were compared and the accuracy of each model was expressed by means of a percentage (Table 2). As for the multiple regression model, the average of deviance is 0.82 and the overall accuracy is 86.3%. Similarly, those from the ANN forecasting model are 0.67 and 88.8%, respectively. It is pointed out that two models are worth predicting the scale-based profitibility for any probable overseas projects by maintainng the reasonable accuracy.

Table 2: Validation of two models

Project #	Level of success (Response)	Regression model (1~7)		ANN model (1~7)	
		Forecasting result	Deviation	Forecasting result	Deviation
1	7	6.71	0.29	6.48	0.52
2	5	4.18	0.82	4.91	0.09
3	5	3.28	1.72	4.28	0.72
4	5	7.00	2.00	6.89	1.89
5	7	6.15	0.85	6.91	0.09
6	7	7.00	0.00	6.49	0.51
7	1	1.00	0.00	0.98	0.02
8	5	2.96	2.04	4.79	0.21
9	5	4.83	0.17	1.83	3.17

Table 2: Validation of two models (continued)

Project #	Level of success (Response)	Regression model (1~7)		ANN model (1~7)	
		Forecasting result	Deviation	Forecasting result	Deviation
10	6	6.28	0.28	6.95	0.95
11	4	5.98	1.98	5.36	1.36
12	6	7.00	1.00	6.08	0.08
13	1	1.00	0.00	1.25	0.25
14	1	1.37	0.37	1.15	0.15
15	2	2.83	0.83	2.10	0.10
Overall Accuracy		**86.3%**		**88.8%**	

7. Lesson learned and Conclusions

All overseas projects are possible candidate for loss due to the risks inherent in the industry. The circumstances of project gain/loss are unique or idiosyncratic to the project and so attempts at generalization are hard to pin down. An important finding of our study, however, was in that overseas projects have some fundamental similarity with regards to the factors that can determine the success or failure in terms of profitability. While the causes of project gain/loss differ in various ways among the project, our research can draw essential and far similar requirements attempting for the profitable projects as a practical suggestion. Particularly, this work contributes to the identification of key variables and the development of prediction models that determine the success or failure of project in terms of profitability. As presented, critical factors of profitability in international construction projects mainly result from (1) quality of estimation such as endowed estimation period and ability of quantity surveyors, (2) project information in early stage such as adequacy of financing，prior bid information & site investigation, country risk-rating, etc, (3) attitude and ability of owner & A/E, (4) contract condition & management ability, (5) project environment and condition such as resource delivery, procurement system, labor skill, etc, (6) commitment of organization such as project manager’s competency and ability of field engineers, and (7) contractor’s ability & experience.

Two kinds of the models in this paper could assign weight to the every 64 risk factors and it can be embodied as an application. It will provide prompt management guideline for the construction companies just by answering the 64 questionnaires at the early stage of project initiations. Stated another way, construction companies are able to screen bad projects such that failure is detected early by paying attention on the critical factors impacting on the profitability. Function of screening out bad projects could improve the financial structures of a corporation. However, forecasting target was focused on scale-based success level of projects because direct earnings ratio could not be collected due to the company's privacy policy. In addition, this paper develops universal models for general construction projects because of limited sample data. Future procedural research will concentrate on establishing specialized models with respect to the different types of project or diverse regional locations by collecting more project samples.

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