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Structuring the prediction model of project performance for international construction projects: A comparative analysis

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Abstract

Early understanding of project conditions is crucial so as to proactively respond to the variable situations of a project. Particularly, international construction projects are affected by more complex and dynamic factors than domestic projects; frequently being exposed to serious external uncertainties such as political, economical, social, and cultural risks, as well as internal risks from within the project itself. This study develops a structural equation model (SEM) to predict the project success of uncertain international construction projects. Through a comparative analysis of SEM with a multiple regression analysis and artificial neural network, SEM shows a more accurate prediction of performance because of its intrinsic ability to consider various risk variables in a systematic and realistic way. In addition, the use of SEM allows for visually depicting the paths of how those complicated variables are interrelated so as to promote the clear understanding of the complex system and its underpinned causes that critically affect the project success.

Keywords: Artificial neural network; Forecasting; International construction projects; Regression analysis; Project success; Structural equation model

1. Introduction

Despite the expanding world construction market that currently reaches approximately 4.6 trillion USD (ENR, 2005; Global insight, 2005), the performance of overseas construction projects has a strong tendency to be weaker than domestic projects. According to Han, Kim, and Kim (2007), foreign construction works are affected by more diverse external risks, such as politics, economy, society, and culture, as well as more dynamic internal risks. To successfully conduct an international construction project, it is important to have an early understanding of the likelihood of the project's success by assessing the level of profitability, probable increase or decrease of planned budget cost, and the grade of schedule performance.

Research has been conducted to produce methodologies that evaluate the project success and selection of a promising project (Chua, Li, & Chan, 2001; Dikmen & Birgonul, 2004; Han & Diekmann, 2001; Mohamed, 2003; Ozorhon, Dikmen, & Birgonul, 2006). These efforts were intended to improve international contractors' performance by supporting a formulation of contract strategies and acquiring profitable overseas projects. However, despite the complexity of underlying structures in predicting possible performance, few researchers have successfully described the inter-relationships and their accurate causal structures in the specific domain of international construction projects. Further, existing approaches are fragmented, which do not cover all of the key performance areas with respect to the project success such as profitability, cost variation, and schedule performance for assessing integrated project performance. This study aims to provide a more organized and accurate model that predicts the key performances of an overseas project by utilizing structural equation model (SEM). The SEM complements multiple regression analysis by considering various project factors in a systematic and realistic manner. This paper further provides theory explanations and research conclusions through a comparative analysis of SEM with multiple regression analysis and artificial neural network (ANN). Finally, the authors draw advantages of SEM over the other two models in this specific research

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domain characterized by unstable, uncertain, and dynamic project conditions.

2. Literature review

Many types of analysis methods have attempted to model complicated prediction processes in construction engineering and management (Diekmann & Girard, 1995; Mohamed, 2003; Molenaar, Washington, & Diekmann, 2000;Pinto & Mantel, 1990; Russell & Jaselskis, 1992; Sanders & Thomas, 1993). These models were developed to fit each subject of interest and the research characteristics—including objectives, intention to use the model, and the scope of data required.

Typically, statistical methods can show a causality of the prediction results to ensure the result in the form of statistically reliable figures. Among those statistical methods, multiple regression analysis is one of the most widely used for modeling because it requires a relatively simple process (Chan, Ho, & Tam, 2001; Diekmann & Girard, 1995; Han et al., 2007; Molenaar & Songer, 1998; Molenaar et al., 2000; Russell & Jaselskis, 1992; Sanders & Thomas, 1993). However, the modeling method using a multiple regression analysis has a significant flaw because it ignores all the potential measurement errors of the observed variables (Bae, 2005). This approach is based on a simple premise that "*independent variables can be measured directly without error, but this assumption often leads to poor quality of prediction*" (Molenaar et al., 2000).

On the other hand, SEM is superior to multiple regression methods because it recognizes the measurement error, and further offers an alternate method for measuring prime variables of interest through the inclusions of latent variables and surrogate variables. The former refers to a hypothetical concept which cannot be directly observed nor measured; the latter is a substitute variable that can be measured directly in lieu of the latent variables. Since SEM was developed by Jöresjig in the 1970s, the use of this model has expanded rapidly with the aid of the development of computer science (Kim & Park, 1996; Kang, Lee, & Choi, 2004; Lee, Kim, & Lee, 2004; Roh, Ahn, & Han, 2005; Sohn, Kim, & Moon, 2007). According to Bae (2005), SEM is considered preferential: (1) to identify a causal relationship between an independent variable and dependent variables by taking the measurement error of the observed variables into consideration; (2) to model a concept that is difficult to directly measure or explicitly quantify; and (3) to represent indirect effects as well as the direct causal or correlation relationships between the diverse and hierarchical variables. In addition, it is possible to visualize the complex relations through a graphical representation that shows the directional paths among variables.

Modeling through SEM has constantly increased in the construction engineering and management area where complex phenomena and dynamic relationships are explored. For example, Mohamed (2003) used SEM to model the joint venture (J/V) performance of overseas construction projects. Molenaar et al. (2000) suggested using SEM to predict the possibility of disputes at the early stage of a project. In another case, Islam and Faniran (2005) modeled the impact of project conditions on planning effectiveness, through SEM application. Wang and Cheung (2005) also proposed an SEM-based prediction model to ensure that partnering can be successfully implemented to realize probable benefits.

As stated, SEM allows users to perform the substantial modeling of the variables' relationships through a path diagram; hence, it is expected that SEM is suitable for overseas construction projects that are confounded by complex and interrelated relations of a myriad of variables. Based on the result of our earlier work (Han et al., 2007), this study aims to model the relationship among various factors and the likelihood of project success through SEM application. This is done in order to evaluate the probable state of a given project condition and to produce strategies to enhance the current conditions surrounding a project. This model will ultimately allow the user to select promising overseas construction projects by examining the key indicators of project performance in advance.

3. Conceptual features of SEM

SEM is a systematic combination of confirmatory factor analysis, multiple regression analysis, and path analysis. It consists of a measurement model and a structural model. The former incorporates confirmatory factor analysis that is concerned with how well latent variables—group factors drawn from factor analysis—are represented by observed variables. The latter reflects multiple regression analysis and path analysis that models the relationship between latent variables and a final outcome (Kline, 2005). The variables of SEM are also classified into an exogenous and endogenous variable depending on whether they influence or are influenced by others. Exogenous refers to an independent variable which influences other variables while endogenous refers to a variable influenced directly or indirectly by other variables. A typical SEM is represented in the forms of an exogenous latent variable, endogenous latent variable, exogenous observed variable, and endogenous observed variable by compounding one with the others. More importantly, SEM has an error variable that capitalizes on both measurement errors and structural errors by accurately reflecting the actual phenomena.

For instance, suppose that the research hypothesis is to test how the "*home background*" of students has an effect on good "*academic performance*" in school. As Fig. 1 shows, since latent variables marked in an oval are difficult to directly measure, "*income levels*" and "*education levels*" of parents are instead engaged to observe "*home background*" that are marked in a quadrangle. The "*academic performance*" is also represented by other observed variables such as "*language grades*" and "*mathematics grades*."