# MAKING INTERNATIONAL EXPANSION DECISION FOR CONSTRUCTION ENTERPRISES WITH MULTIPLE CRITERIA: A LITERATURE REVIEW APPROACH

**Abstract**

Multi-criteria Decision Making (MCDM) methods have been instrumental in various fields of disciplines such as economics and engineering, including construction studies. In the later context, MCDM methodology has been adopted to unravel the decision-making problems as regards international expansion of construction enterprises (IECE). This paper presents a literature review of the methodology designed as decision support system for IECE. A methodological literature search to collect and identify relevant articles was utilized in top tier *Construction Management* journals. This study performs content analysis based on problem oriented MCDM applications in IECE. Theoretically, MCDM techniques were used in five contexts of IECE problems; internationalization decision, country or market selection, entry mode selection, project selection or bidding decision, and other related international expansion. The types and complexity of problems were dominated by risks in international projects. Both real and simulation data were used to execute and validate the proposed MCDM models. This paper also suggested a number of possible future studies in applying MCDM methods for supporting IECE decision.

**Keywords**: International expansion, construction enterprise, expansion decision, decision making, multi criteria, MCDM, content analysis, literature review.

# INTRODUCTION

International expansion of construction enterprises (IECE) has been taking place for many years. Unlike domestic projects, overseas works are immensely intricate due to a blend of the construction industry's nature and foreign country's environment. This state of affairs causes a complex scenario in decision making process of IECE. Thus, the initiative to *go international* constitutes a consequential decision which considerably impacts on the company's operation (Hawk 2006; Tang et al. 2012).

Traditionally, the difficulties in making decision on every strategic issue exists due to the existence of multiple criteria that should be considered, different perspective of decision makers, risk and uncertainty, and vagueness of information (Singh and Tiong 2005). A large amount of data and knowledge which have to be processed also equips the intricacy of the decision-making process (Jato-Espino et al. 2014). To deal with these circumstances in which the modest methods cannot resolve, Multi-criteria decision making (MCDM) methods were introduced (Moselhi and Martinelli 1990). MCDM methods provide several logical-scientific approaches to help unravel the decision making problems (Tam et al. 2007).

Indeed, several attempts to review the application of MCDM techniques in the knowledge of construction field were carried out. The latest studies in this context are a review of MCDM applications in civil engineering (Zavadskas et al. 2015), in the construction area (Jato-Espino et al. 2014), and in infrastructure management (Kabir et al. 2014). Instead of critisizing the nature, context and complexity of the problems involved in the construction industry, those tend to lead the analysis and discussion in the perspective of statistical figures. Whereas, MCDM topics in the context of IECE have been disregarded in scientific literature.

Different industries require different information in addressing the problems resulted of the difference of the industry's natures (Wood and Goolsby 1987). As a part of construction business, international construction projects (ICPs) entail the specific applicative approaches to deal with the typical blended problems of construction project and foreign environment. Therefore, the present study looks into the ICP research with a view to understand the role of the MCDM methods for international expansion decision. This study provides a problem oriented review and observes to what extent MCDM techniques were utilized for decision support in IECE. The successful application of MCDM methods in various disciplines has evidenced that this methodology may also benefit construction management area. Therefore, the contribution of this study is to provide a useful insight for the promotion of MCDM methodology in directing future ICP research.

## OVERVIEW OF MCDM APPLICATIONS IN IECE

*Analytical Hierarchy Process* (AHP) has been used widely due to its simplicity in application and flexibility to collaborate with other methods. Hastak and Shaked (2000) employed AHP method to develop the International Construction Risk Assessment Model (ICRAM-1). The model assists the decision makers in assessing the latent risks affecting the market expansion abroad. Gunhan and Arditi (2005a) developed a model framework to facilitate the expansion decision making into foreign markets through a combination of AHP and the Delphi technique. Another amalgamation of AHP and Delphi was employed to assign relative weights to entry modes (Gunhan and Arditi 2005b). The model is a practicable notion for executives enabling them to rate their company's position against market expansion internationally.

Han et al. (2008) developed a web-based tool to deal with the specific needs of different types of risks in international construction project stages. AHP was used to draw the relative importance

among the five highest-order criteria based on eliciting the opinions of 52 Korean overseas construction firms when making bid decisions and the selection of overseas projects and a *Simple multi-attribute rating technique* (SMART) was employed to determine relative weights among the lower-order 36 attributes. A model was then developed using *factor analysis* and *multiple regression analysis* to identify the causal relationships between the level of profit and the risk variables. A hybrid AHP-*Preference ranking organization method for enrichment evaluation* (PROMETHEE) was utilized to select an entry mode for construction firms involved in international markets (Li et al., 2013). The AHP technique was used to break-down the entry mode problem into several attributes and to determine the weight of each criterion. The PROMETHEE was employed to rank entry modes and to carry out a sensitivity analysis.

Chan et al. (2006) combined the AHP and Multi Attribute Utility Theory (MAUT) to advocate a selection model of a dispute resolution for construction professionals involved in international projects. The objectives are to plot a dispute with the most appropriate resolution technique. Inspired by a company's strategic analysis in assigning permanent staff and hiring local temporary workers in foreign projects, Lin (2011) studied human resource allocation problems in international construction management and introduced a decision-making model. The model estimates total project cost (the expenses and loses) through an evaluation of the permanent and local staff proficiency in ICPs. Lin particularly employed AHP and Delphi technique to analyze personnel proficiency as Project Administrators and Site Engineers.

Bu-Qammaz et al. (2009) proposed the *Analytical Network Process* (ANP) to arrange the interrelations between risks related factors as a trustworthy method for rating the level of risk associated with ICPs. The principle of this model is to assist the decision makers to estimate the risk ranking so that alternative projects may be ranked. Ölçer and Akyol (2014) developed an Excel

spreadsheet-based decision support tool to rate the target countries by considering the risks and opportunities offered. In their study, a combination of *Decision-making trial and evaluation laboratory* (DEMATEL) and ANP was used to rate the countries under consideration. DEMATEL was utilized to determine the causal relationship among criteria and ANP was used to determine the weights of the elements which include various criteria, i.e., technical, economic-financial, market promotion, political, operational and, social-cultural. Ölçer and Akyol claimed that the system is user friendly and can assist as a practical guiding framework for international expansion by examining the candidate of potential countries' score under different criteria.

Han and Diekmann (2001) promoted a concept for making stable and systematic procedure risk-based go/no go decision making process using the *Cross Impact Analysis* (CIA) method. In this model, they applied knowledge deriving from previous research and the input of international experts. The project's profit concept is a main criterion set as a trigger for making decisions. This application could develop different scenarios used to assess variable sensitivity and come up with probabilistic multiple criterion outputs. In another study, Han et al. (2005) employed CIA to clarify the risk attitude of contractors in bid decisions regarding foreign projects. Here, CIA processed two objectives; project profitability and other benefits to the projects. The decision makers then determine the weight of both objectives to decide *go bidding* or vice versa.

Ozorhon et al. (2006) developed a model using Case-Based Reasoning (CBR) to support the decision-making process of international market selection. This model aims to forecast a project's potential profitability and competitiveness level of a company under given conditions. CBR exhibits how companies learn from its competitors' experiences in international projects and improve their decision-making abilities. Similarly, due to the unstructured decision-making problem in bid mark-up estimation, Dikmen et al. (2007) proposed a decision support system

which systematically estimate the bid mark-up value for project bidding. This technique utilized CBR to rate risk, opportunity and competition level in ICPs. The ratings are then transformed into risk and profit mark-up values using *linear utility functions*. The authors believed that the proposed technique is a concrete method of solving the mark-up estimation problems, because the dependency of the decision makers on their instinctive knowledge in making a prediction can be dodged.

Han et al. (2004) studied on the *financial portfolio risk management* for international projects. They introduced a procedural framework of project-selection for multinational contractors by integrating the risk hierarchy of individual projects and the corporate level. The initial concept of this study was to help companies to select a project contributing to that company's portfolio enhancement. Kim et al. (2013) adopted the *Real-options* theory, originally from the financial industry, for a model of market-entry decision making in international construction businesses. The model is directed to price the revenue volatility in a foreign market. The authors claim that this model can portray the optimal entry and exit time when penetrating foreign markets.

The fuzzy technique is a mathematical theory widely employed for solving fuzzy decision-making problems (Chen and Tan 1994). It uses linguistic forms as representing numerical parameter variables. Dikmen et al. (2007) utilized this theory to developed a computerized system along with the *influence diagram* to rate cost overrun risk in ICPs. Fuzzy set theory was applied to set membership function of risk variables. To aggregate output variables (risk rating) used to determine project risk levels, the Fuzzy *IF-THEN* rule was employed. In different form of the fuzzy, Cheng et al. (2011) integrated the *Fuzzy preference relation* (FPR) and the *cumulative prospect theory* (CPT) for decision support to enter foreign markets.

The cost of political risk is one aspect affecting construction firms' decision to enter into project bidding in foreign markets. Al-Tabtabai and Alex (2000) disseminated the intelligent of the *Artificial Neural Network* (ANN) to predict the cost of political risk for ICPs. This application employed experts' knowledge and experience involved in risk assessment. ANN is a very adaptive technique offering a better solution for very complex problems containing the nonlinear relationships (Wanous et al. 2003). The power of the ANN technique was also exploited by Dikmen and Birgonul (2004) to develop a strategic model of decision to enter foreign markets. Project attractiveness and company competitiveness were set as outputs of the model, while 16 criteria affecting the attractiveness and competitiveness were considered as input variables. The back-propagation technique was used as *learning* method in training the neural network model.

Although new advance techniques were established, statistical methods are still relevant to support decision in multi criteria environment. Chen and Messner (2011) utilized a *binary logistic regression* analysis to develop a model for choosing the entry mode. They adopted a similar concept of the international business discipline to define hypotheses related to the effect of the company and home-country related factors upon making the entry mode selection. Analysis on the entry mode selection decision was undertaken by using hypothesis testing. Han et al. (2007) used f*actor analysis* and *multiple regression analysis* to develop a model for choosing a potential international project through predicting its profit performance. The approach was functioned as *a systematic risk-screening tool* which is operated to define, analyze and evaluate different influencing risk variables. Using the two methods, a range scale-based profit prediction model to opt candidate international projects was developed.

*Correlation* and *regression* analysis were utilized to discover the most important risk factors impacting project cost contingency during the bidding stages of ICPs (Sonmez et al. 20007).

Correlation analysis was harnessed to assign a linearity rate between risk factors and contingency, while regression analysis was used to develop a model quantifying the impact of factors on contingency. Kim et al. (2008) introduced a predictive tool which can evaluate categorical ranges of possible cost variances by using *linear discriminant analysis*. This analysis can predict groups of dependent variables from categorical criteria or variables (Malhotra 2010). The model allows the decision makers to determine a reasonable cost contingency rate which is useful for entering a foreign project market bidding.

Over the years, risk management methodology has been applied in various fields of construction project decision making. In ICP studies, Han et al. (2008) developed an integrated risk management system to tailor specific requirements of different type of risks. This model is a web-based system facilitating decision makers to check and monitor different risks eminent at every level of the ICP life cycle in real-time. Risk management techniques were utilized by Gad et al. (2011) to develops an analytical framework of dispute resolution method called as DRM-Risk matrix. This model analyzes risks expected in ICPs and based on the analysis, decision makers can determine a suitable dispute resolution technique. This analysis involves three steps of risk management methodology; dispute risk identification, dispute risk assessment and dispute risk control. This model helps the involved parties in ICPs to deliberate contractual clauses related to dispute settlements.

## METHODOLOGY

The identification of relevant papers was conducted by adopting a methodical document search promoted by Osei-Kyei and Chan (2015) and Utama et al. (2016). Two reputable international journal databases, Scopus and Web of Science (WOS) were exploited to filter relevant articles published from 1995 to present. The output quantity and influence factor are the reasons behind

178 the selection of the databases (Aghaei-Chadegani 2013). Guz and Rushchitsky (2009) affirm that
179 the databases extensively embrace various knowledge domains and are the most frequently
180 exploited for reference searching.

181 The key words such as *decision making* and *international construction* were employed as a set of
182 search code. *Try-error* combination with one of following words such as *multi-criteria*; *multi-*
183 *attribute*; and *multi-objective*, were used to narrow the search area. The term *international*
184 *construction* was alternately modified by related terms such as *international projects*, *international*
185 *construction projects* (ICPs), and *overseas projects*. The choice of articles was firstly based on a
186 list of peer-reviewed journals on the basis of construction management studies, as referred by Chau
187 (1997). However, based on the authors' observation, currently, the scope of journals does not
188 merely focus on a single discipline, but also crosses over the body of knowledge. Therefore, to
189 increase the possibility to collect relevant papers, the above search encryptions were also typed in
190 the Google Scholar search engine.

191 Despite statistically counting, this study aims to perform a problem oriented review of MCDM
192 methods for supporting decision in IECE. In this paper, MCDM methods refer to techniques or
193 approaches (e.g. AHP, ANP, CBR, Fuzzy and ANN) adopted to design or develop a decision-
194 making model. A content analysis technique instead of meta-analysis was ascertained as an
195 appropriate approach to establish this outcome. Some scholars opine content analysis as a flexible
196 approach to document analysis (Elo and Kyngäs 2008; Hsieh and Shannon 2005). This method
197 reveals an investigative technique subdivision based on subjective reactions, instinctive,
198 explanatory to systematic and rigid verbatim analysis (Rosengren 1981). Its objective is *"to*
199 *provide knowledge and understanding of the phenomenon under study"* (Downe-Wamboldt 1992).

Identification of the substantive interest and determination of type of content analysis are the steps for undertaking a content analysis (Fellows and Liu 2008). The qualitative content analysis was considered by conducting an in-depth study of the content of articles. Qualitative content analysis tends to subjectively analyze the content of script data and then methodically coded and grouped based on topics or arrays (Hsieh and Shannon 2005). Two essential issues considered are (1) the nature and context of the problems and (2) type and complexity of the problem behind the MCDM applications. There was not a bigotry of choosing the MCDM methods contained in relevant papers. Several techniques of decision analysis often used as complementary instruments such as discriminant analysis, regression analysis and risk management method were also taken into account.

## GENERAL ANALYSIS AND DISCUSSION

MCDM is a wide-ranging and well-established paradigm for dealing with multi-dimensional problems involving various criteria, objectives and several decision makers. In addition, the characteristics of problems in ICPs perfectly reflects the condition where MCDM methods may help addressing such environments. There are currently unimpressive MCDM applications in ICP especially for supporting decisions of IECE. Only twenty-six articles relevant to the context were successfully identified after conducting an extensive literature search. However, there are several general conclusions that are worth calling attention upon the MCDM applications after a perusal of each article. In the following section, a content-oriented discussion is presented and discussion is grouped into two sub-sections: (1) the nature and context of the problem and (2) type and complexity of the problems.

## The Nature and Context of the Problems

Table 1 presents the references of MCDM applications in ICP ranging from 2000 to recently. They were functioned mostly in factual data for illustrating examples rather than simulated ones. The real data used to analyze and test the models includes completed project records (e.g. Dikmen and Birgonul 2004; Bu-Qammaz et al. 2009) and case studies (e.g. Gunhan and Arditi 2005b; Li et al. 2013). The simulated data comprises case-made experiments of a decision maker group (e.g. Han and Diekmann 2001a, 2001b; Han et al. 2005) and illusive simulations (e.g. Kim et al. 2013; Cheng et al. 2011). In term of methodology, the use of AHP, both single and hybrid application, was dominantly adopted.

[Insert table 1 here]

Different topic areas of IECE in which MCDM methods have been employed could be grouped into five categories; (1) the internationalization decision, (2) country/market selection, (3) entry mode selection, (4) project selection or bidding decision, and (5) miscellaneous international expansion. The classification was made based on the identification and analysis of the objectives of the studies and the hierarchy process of the developed models.

Internationalization decision refers to the management decision to expand company's market overseas (Dikmen et al. 2007), while Gunhan and Arditi (2005b) viewed whether the company qualifies for contemplating to enter foreign markets. In evaluation of a company's qualification and readiness to export their services, a SWOT (strength, weakness, opportunity and threat) analysis is one of the favorite approaches commonly used by a company's management. During such evaluation, subjectivity of managers in assessing each element cannot be avoided. For this reason, MCDM techniques can be integrated in a SWOT analysis as proposed by Gunhan and Arditi (2005b). The application of the MCDM method for this purpose was supported by AHP

244 improved by Delphi method. Both techniques were joint to evaluate a company's readiness both
245 internally and externally relative to trade internationally. The AHP was used to assess a pairwise
246 comparison between a company's strength factors and to assign the potential threats and
247 opportunities factors faced by the company in conducting international projects. The Delphi
248 technique was employed to generate consensus among the experts in conducting the pairwise
249 comparisons. This approach provides a parameter indicating that the company is eligible for
250 international expansion. So far, no other MCDM models were employed anywhere else in the
251 context of internationalization decision.

252 Country or market selection refers to the examination of the potential countries to be penetrated.
253 For this purpose, the companies considered the prospective markets or countries such as those
254 offering high return, opportunity for growth, easiness in operation and lowest risk potential. The
255 use of MCDM tools for this area is quite favorable regarding the number of applications. Table 1
256 demonstrates four stand-alone (CIA, ANN, CBR and Real Option) and three mixed MCDM tools
257 (AHP-Delphi, DEMATEL-ANP, and FPR-CPT) supporting decision making in the context of a
258 feasible market choice. The difficulty of dynamic multi-level of go/no go decision procedure and
259 to obtain the inter relationships among risk variables accurately, are the nature and context of
260 problem found by Han and Diekman (2001b). By proposing the ANN approach, Dikmen and
261 Birgonul (2004) highlighted the problem in collecting valuable information during international
262 project operation and in ranking the list of countries/markets' priority to be implemented in a
263 strategic plan. Furthermore, the overseas market or country selection problems were also
264 confronted with two major analytical methods, AHP and ANP combined with the Delphi and
265 DEMATEL techniques respectively. Gunhan and Arditi (2005b) who capitalized on the AHP-
266 Delphi technique, underlined the evaluation of the company based on the benefit of undertaking

foreign projects and cost associated with the penetration into a particular market. Unlike the AHP-Delphi approach, the DEMATEL-ANP amalgamation was synergized by Olcer and Akyol (2014) to opt a specific country by stressing on the country's rating by considering the identified criteria called as TEMPOS. Technically, this method makes use of a spreadsheet application enabling decision makers to enter their own criteria.

Entry mode selection refers to the evaluation of the alternative strategies to enter particular foreign markets. The choice of entry mode type is a crucial step which may determine the success of a company in penetrating foreign country markets. Based on a literature search shown in Table 1, similar to the MCDM applications employed for internationalization decisions, the use of this methodology is also rare for choosing the entry mode. Table 1 denotes three MCDM applications for this purpose, however only two applications, the AHP-Delphi (Gunhan and Arditi 2005b) and the AHP-PROMETHEE (Li et al. 2013) techniques to directly address to a specific entry mode which has to be selected. Another method called the *binary logistic regression* (Chen and Messner 2011) is not specifically directed to examine entry modes but tends to evaluate the best choice between permanent and mobile entries.

Project selection or bidding decisions refer to the analysis of single or several international projects and to make the decision to bid or not to bid. Traditionally, project selection in general has been approached through quantitative financial techniques such as net present value, return on investment, discounted cash flow and payback period (Shakhsi-Niaei et al. 2011). These methods merely depend on economic financial features such as interest rate, initial and operational cost but they tend to overlook other multi criteria, out of financial factors, effecting the project choice. For this reason, the use of MCDM techniques are actively encouraged. A number of MCDM techniques have been used to tendering decisions and selection process of any kind of construction

290 project. However, there are obvious differences in terms of criteria used in MCDM applications in
291 which risks at country level with 28 factors (Hastak and Shaked 2000) and country factors level
292 with 12 factors (Cheng et al. 2011) are the most conspicuous. Almost similar to the three
293 aforementioned contexts, MCDM applications for targeting international project selection or
294 tender decision were considered as they systematically assist decision making in examining factors
295 effecting ICP. For this purpose, the risk management concept is often paired with MCDM tools
296 such as AHP (Hastak and Shaked 2000), ANP (Bu-Qammaz et al. 2009) and CIA (Han et al. 2005).
297 Other related international expansion refers to the use of MCDM techniques other than the
298 four types above such as prediction of mark-up (Dikmen et al. 2007; Kim et al. 2008) and
299 selection of dispute resolution mechanism in international project (Chan et al. 2006; Gad
300 et al. 2011). By and large, the main consideration of MCDM techniques use is similar to
301 other areas where traditional approaches cannot fully address the multiple variables
302 involved in decision-making. Another robust reason is that MCDM may minimize
303 subjectivity of decision-making due to the lack of relevant information for making
304 judgement.

305 **Type and Complexity of Problems**

306 The type and complexity of problems presented in Table 2 reflect the setting of the environment
307 in which decision are to be made. Overall, risk problems dominantly influenced the application of
308 MCDM methods for IECE followed by international factors. A majority of studies show different
309 numbers of criteria involved, meaning that there have been no fixed criteria affecting ICP agreed
310 upon by researchers. The categorization of the criteria is not their concern either. The identification
311 and determination of criteria fully depended on the authors' decision after having conducted a
312 literature review and the results from a survey done amongst experts.

313 [Insert Table 2 here]

314 The AHP was used to measure the weight of risk indicators to set the priority among the criteria,
315 sub-criteria, and indicators in the studies by Hastak and Shaked (2000) and Han et al. (2008).
316 Similarly, the ANP was also utilized to determine the relative weight of interrelation risk factors
317 as an input to a decision model (Bu-Qammaz et al. 2009 and Ölçer and Akyol 2014). Studies of
318 ICP also highlighted in particular the criteria in the context of political risks (Al-Tabtabai and Alex
319 2000), financial risks (Han et al., 2004), and project and country risks (Sonmez et al. 2007) where
320 the ANN, financial portfolio and regression analysis were used respectively. Unlike the AHP and
321 ANP method, the three last mentioned approaches were employed without previously measuring
322 the preference ranking between the criteria.

323 Several papers used the term '*international factors'*. In fact, they are principally akin to the risk
324 factors mentioned above. Home country and firm specific factors and control variables are
325 international factors categorized by Chen and Messner (2010) when selecting an appropriate entry
326 mode by using statistical regression analysis. FPR was employed to obtain relative weights of
327 country factors (e.g. monetary inflation, bureaucratic delay, societal conflict) and project factors
328 (e.g. availability of workers, weather conditions, availability of basic construction technology and
329 equipment) (Cheng et al. 2011). Again, the AHP was used to examine the weight of international
330 factors consisting of national factors, international environment, international strategy, enterprise
331 and industry, and intrinsic features of entry modes (Li et al. 2013).

332 The project attractiveness and company competitiveness were promoted to delineate attributes
333 affecting ICP. Sixteen criteria such as prosperity of host country, host country risk, size and type
334 of project, type of client, etc., were used to develop an ANN model (Dikmen and Birgonul 2004)
335 and the CBR model (Ozorhon et al. 2006) separately. In these models, the criteria were set as input

while as the outputs of the network were project attractiveness and company competitiveness. The difference is that the CBR uses a case data bank where the past projects were stored to be reused in analyzing new projects, while the ANN needs a number of past cases as training data to develop a stable network.

Decision making is also influenced by a company's strength factors relating to foreign markets (e.g. project management capability and financial strength), threat factors posed by international markets (e.g. inflation, currency fluctuation and interest rate), and opportunity factors offered by overseas market (e.g. availability of new market and technological advancement). For these types of problems, the AHP and Delphi were integrated to assess a pairwise comparison between strength factors relative to international construction, and to evaluate the benefit and opportunity factors (Gunhan and Arditi 2005a, 2005b). Other minor types and problem complexities detected from IECE were dispute risk (Chan et al. 2006; Gad et al. 2011), investment problems (Kim et al. 2013) and personnel management (Lin 2011).

Dealing with uncertainties may increase decision making precision, otherwise, they may induce incompetently defined alternatives or options (Kangas et al. 2000). Uncertainty occurs because of ill-defined information, discrepancies among information sources, imprecise language, simplification, or supposition (Kim et al. 2008). Many situations in international projects contribute to uncertainty because the data cannot be described properly or predicted deterministically, such as future political and economic condition in the host country, and also subjective judgements by decision makers.

To minimize uncertain judgement regarding the weight of decision-making criteria, deterministic approaches often used are based on the sensitivity analysis and outranking methods such as PROMETHEE (Mendoza and Martin 2006). Example of this application can be found in Li et al.

(2013) in choosing an entry mode for IECE. The evaluation differences among ranking preferences made by decision makers is tackled by PROMETHEE. Tang et al. (2012) demonstrated the use of the entropy ranking analysis method to reduce uncertainty between surveyed participants and unravel the weighting problems of multiple criteria. Dikmen et al. (2007) employed the utility theory to rationalize the decisions made by different decision makers when considering mark-up values. Kim et al. (2008) made use of a statistical method, discriminant analysis, to manage uncertainty when forecasting cost variances between planned and actual in international projects. In addition, imprecise data may arise uncertainty due to invalid sources. To deal with this environment, probabilistic approaches may not be applicable because of ambiguous output (Mendoza and Martins 2006). In such a case, the problem with ambiguous data may be solved by setting into linguistic form based on the fuzzy logic concept. This concept can be found in a study by Dikmen et al. (2007) who utilized the Fuzzy set theory to the assess final cost overrun risk rating.

## IMPLICATIONS FOR THE FUTURE RESEARCH DIRECTION

From the overview and discussion described in previous sections, additional research areas have been identified in which decision-making models can be developed using MCDM techniques with regards to further studies. Four highlighted points which are advocated for directing future research are as follows:

1. It is recommended that the use of MCDM methods in the topic of internationalization decision-making process, can be intensively explored. In this topic, the MCDM models may be addressed to assess the capability of enterprises to operate outside their market of origin. In such decision, intuition and past experience of decision makers in judging capability of the firm may be more dominant. Indeed, the intuition of decision makers plays an important role in strategic decision

382 making (Khatri and Ng, 2000). Thus, the choice of appropriate MCDM techniques allowing an
383 interactive approach to be accommodated. Pairwise comparisons can be utilized as interactive
384 styles to involve decision makers (Korhonen et al., 1992). In the same time, subjectivity of
385 decision makers in this process is undeniably exposed to different experiences and references.
386 Therefore, the use of a hybrid MCDM methodology corresponding both decision makers'
387 interaction and reduce subjectivity will have a robust reason.

388 2. Similarly, entry mode selection is equally important in IECE. However, the use of MCDM
389 methods to design decision support models in this topic is inadequate. The selection of an
390 eminently suitable entry mode may determine the future company's fruitfulness in foreign
391 target market. Each entry mode has different characteristic, advantages and disadvantages.
392 MCDM methods may be adopted to assess the fitness between the nature of entry mode and
393 host country or project environment.

394 3. A dozen MCDM models have been developed, but only sixteen techniques have been used in
395 IECE studies. There is opportunity to explore other MCDM techniques either by single or by
396 hybrid approach for supporting expansion decision-making. The construction industry may
397 learn from other advanced industries such as manufacturing and finance in employing MCDM
398 approaches with necessary adjustment.

399 4. The fuzzy set theory has been widely employed for decision -making, measuring productivity,
400 cost and time performance, evaluation and assessment of risk. This concept considers the
401 complexity, uncertainty and ill-defined information. Fuzzy concepts, *membership functions* and
402 *linguistic variables*, can fit to solve the problem of the international project environment.
403 Furthermore, the ANN offers an auspicious management method in several potential areas such
404 as selection between alternative, estimation, classification, and optimization tasks. The ANN

has been used due to its ability to improve available automation efforts, including expert system applications. Correspondingly, the realm of construction engineering and management activities require expert knowledge, judgment, and experience for their problem resolutions. For these reasons, this discipline is the best practical workshop for applying many expert system techniques (Moselhi et al. 1991). Therefore, both artificial intelligence methods can be applied extensively to support decision-making for IECE.

## CONCLUSION

This article presented a literature review of MCDM applications to support decision-making for IECE. It is unarguable that MCDM offers several logical frameworks for making decisions in addressing many problems within ICPs. Based on the article retrieval method from major construction management journals, the present study reviewed 26 papers relevant to the context. Although the number of articles discussed is scanty, those used were found to be practical. MCDM models were developed mainly to facilitate the decision-making process for addressing *multiple criteria/attributes/objectives/dimensions* accompanying the problems. They can improve the efficiency of the decision making process.

Two main focus points of literature review in this literature review were the context and complexity of problems setting in the applications. These problems have been challenging for both academia and practitioners to explore innovative approaches in decision making. In respect to the first focus, this study discovered that the internationalization decision and entry mode selection have not been explored intensively. In the second focus, the international construction risks and international factors were of the most concern of all applications. Both underlying issues are still valid for further MCDM applications for international expansion decision making.

As a final remark, it should be noted that this study, although it has made a serious effort to collect and review relevant studies, cannot be claimed to be comprehensive and exhaustive. It is possible that some relevant articles have been overlooked due to the fact that the publication retrieval was merely from selected construction management journals. Furthermore, this study was not intended to compare and contrast MCDM methods used in each application. This study proposed four subjects to be explored intensively as future research endeavors.

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562 167.

563 Table 1. MCDM applications systemized according to context of problem and type of data used.

| Ref. No. | Authors | Decision Support Tool | Context of the problem | | | | | Illustration example | Annotation for (5) |
|---|---|---|---|---|---|---|---|---|---|
| | | | (1) | (2) | (3) | (4) | (5) | | |
| [1] | Hastak, M. and Shaked, A (2000) | Risk management + AHP | | | | √ | | Simulation | |
| [2] | Al-Tabtabai, H. and Alex , A.P. (2000) | ANN | | | | | √ | Real | Project cost estimation |
| [3] | Han, S.H. and Diekmann, J.E. (2001a) | CIA | | √ | | | | Simulation | |
| [4] | Han, S.H. and Diekmann, J.E. (2001b) | CIA | | √ | | | | Simulation | |
| [5] | Dikmen, I. and Birgonul, T.M. (2004) | ANN | | √ | | | | Real | |
| [6] | Han, S.H., Diekmann, J.E., Lee, Y. and Ock, (2004) | Financial Portfolio Risk Manage. | | | | √ | √ | Simulation | |
| [7] | Han, S.H., Diekmann, J.E. and Ock, J.H. (2005) | CIA Based Risk attitude | | | | √ | | Simulation | |
| [8] | Gunhan, S. and Arditi, D. (2005a) | AHP + Delphi | √ | | | | | NA | |
| [9] | Gunhan, S. and Arditi, D. (2005b) | AHP + Delphi | √ | √ | √ | | | Real | |
| [10] | Ozorhon, B., Dikmen, I. and Birgonul, M.T. (2006) | CBR | | √ | | | | Real | |
| [11] | Chan, E.H.W., Suen, H.C.H.and Chan, C.K.L. (2006) | MAUT + AHP | | | | | √ | NA | Dispute resolution choice |
| [12] | Han, S.H., Kim, D.Y. and Kim, H. (2007) | Multi regression analysis | | | | √ | | Real | |
| [13] | Dikmen, I., Birgonul, T.M. and Gur, K.A (2007) | CBR + Utility Theory | | | | | √ | Real | Bid mark-up estimation |
| [14] | Dikmen, I., Birgonul, T.M. and Han, S. (2007) | Fuzzy logic | | | | | √ | Real | Cost overrun risk rating |
| [15] | Sonmez, R., Ergin, A. and Birgonul, T.M. (2007) | Regression analysis | | | | | √ | Real | Bidding contingency decision |
| [16] | Han, S.H., Kim, D.Y., Kim, H. and Jang, W.S. (2008) | AHP + Risk Management | | | | √ | | Real | |
| [17] | Kim, D.Y., Han, S.H. and Kim, H.K. (2008) | Discriminant analysis | | | | | √ | Real | Bid mark-up estimation |
| [18] | Bu-Qammaz, A.S., Dikmen, I. and Birgonul, M.T. (2009) | ANP | | | | √ | | Real | |
| [19] | Chen, C. and Messner, J.I (2011) | Binary logistic regression | | | √ | | | NA | |
| [20] | Cheng, M.Y., Tsai, H.C. and Chuang, K.H. (2011) | FPR and CPT | | √ | | √ | | Simulation | |
| [21] | Gad, G.M., Kalidindi, S.N., Shane, J. and Strong, K. (2011) | Risk Management | | | | | √ | NA | Dispute resolution choice |
| [22] | Lin, K.L. (2011) | AHP | | | | | √ | Real | Human resource allocation |
| [23] | Tang, L.C.M., Atkinson, B. and Zou, R.R. (2012) | Entropy ranking + SWOT Analysis | | | | | √ | Real | Critical success factors |
| [24] | Kim, D.Y., Ashuri, B. and Han (2013) | Real-option analysis | | √ | | | | Simulation | |
| [25] | Li, H., Jin, Z., Li, V., Liu, G. and Skitmore, R.M. (2013) | AHP + PROMETHEE | | | √ | | | Real | |
| [26] | Ölçer, M.G. and Akyol, D.E. (2014) | DEMATEL + ANP | | √ | | | | NA | |

Note: (1) Internationalization, (2) country/market selection, (3) entry mode selection, (4) project selection or bidding decision, (5) other related ICP. NA – Not available.

564 Table 2. MCDM applications systemized according to complexity of problem.

| Ref. No. | Decision Support Tool | Type of problem | Number of Criteria/ Category | Type of category | Deal explicitly with uncertainty |
|---|---|---|---|---|---|
| [1] | Risk manage. + AHP | Risk in ICP | 73/3 | (1) macro or country level risk; (2) market level risk; (3) project level risk. | NO |
| [2] | ANN | Political risk in ICP | 6/- | (1) firm relationship to government; (2) firm relationship to power group; (3) involvement of local business interest; (4) impact of external and regional factors; (5) nationalist attitude toward the firms; (6) project desirability to host country. | YES |
| [3] | CIA | Risk in ICP | 33/5 | (1) political risk; (2) economic risk; (3) cultural/legal risk; (4) technology/construction risk; (5) other risks. | YES |
| [4] | CIA | Risk in ICP | 33/5 | ditto. | YES |
| [5] | ANN | International factors, project attractiveness and company competitiveness | 16/- | project attractiveness and company competitiveness. | NO |
| [6] | Financial Portfolio Risk Manage. | Financial risk in ICP | 3/- | financial risk. | YES |
| [7] | CIA Based Risk attitude | Contractor's risk attitude | 5/- | (1) expected return; (2) significant loss; (3) significant gain; (4) variations in loss; (5) chance of gain. | YES |
| [8] | AHP + Delphi | SWOT factors and International factors | 38/6 | (1) company strength; (2) threat posed by international markets; (3) opportunities presented by international markets; (4) benefits conducting business overseas; (5) cost conducting business overseas; (6) international expansion modes | NO |
| [9] | AHP + Delphi | SWOT factors | 21/3 | (1) company strength; (2) threat posed by international markets; (3) opportunities presented by international markets. | NO |
| [10] | CBR | International factors, project attractiveness and company competitiveness | 16/- | project attractiveness and company competitiveness | NO |
| [11] | MAUT + AHP | Dispute in ICP | 9/- | selection factors. | NO |
| [12] | Multi regression analysis | Risk affecting profitability | 64/5 | (1) condition of host country and project owner; (2) bidding process; (3) project characteristic and contractual conditions; (4) characteristic of organization and participants; (5) contractor’s ability. | NO |
| [13] | CBR + Utility Theory | International factors, opportunity and competition | 44/4 | (1) general; (2) risk; (3) opportunity; (4) competition. | YES |
| [14] | Fuzzy logic | Risk in ICP | 13/2 | (1) country risk; (2) project risk. | YES |
| [15] | Regression analysis | Project and country risks | 53/2 | (1) project risk; (2) country risk. | NO |
| [16] | AHP + Risk Manage. | Risk in ICP | 36/5 | (1) project characteristic and importance; (2) level of bid competition and market condition; (3) degree of potential profit; (4) contractor position and ability to perform; (5) degree of representing risk exposures. | NO |
| [17] | Discriminant analysis | Risk in ICP | 64/6 | (1) condition of host country and project owner; (2) bidding process; (3) project characteristic and contractual conditions; (4) characteristic of organization and participants; (5) contractor’s ability. | YES |
| [18] | ANP | Risk in ICP | 28/5 | (1) country; (2) inter country; (3) project team; (4) construction; (5) contractual. | NO |
| [19] | Binary logistic regression | International factors | 16/2 | (1) home country and firm’s specific variables; (2) control variables. | YES |
| [20] | FPR and CPT | International factors | 24/2 | (1) country factors; (2) project factors. | NO |

| | | | | | |
|---|---|---|---|---|---|
| [21] | Risk Management | Dispute risk in ICP | 9/2 | (1) project specific risk; (2) external risk. | NO |
| [22] | AHP | Personnel management | 13/4 | (1) professional background; (2) personal characteristic; (3) teamwork capability; (4) interpersonal skills. | NO |
| [23] | Entropy ranking + SWOT Analysis | Critical success factors and SWOT | 11 and 25 | critical success factors and SWOT factors. | YES |
| [24] | Real-option analysis | Investment problem | 4/2 | (1) cost cash outflow components; (2) capital structure of firm | YES |
| [25] | AHP + PROMETHEE | International factors | 20/5 | (1) national factors; (2) international environment; (3) international strategy; (4) enterprise and industry factors; (5) intrinsic feature of entry mode. | YES |
| [26] | DEMATEL + ANP | International factors | 108/6 | (1) technical; (2) economical and financial; (3) market promotion; (4) political; (5) operational; (6) social cultural. | NO |