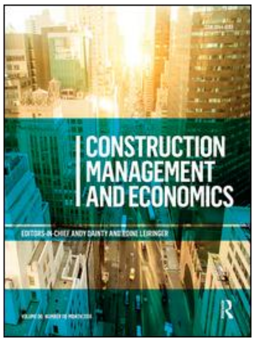

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Making a risk-based bid decision for overseas construction projects

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The globalization of international construction markets provides tremendous opportunities for contractors to expand into new foreign markets. However, entry decisions for international construction markets are very risky and more difficult than those for domestic markets, due to the wide variety of uncertainties and complexities associated with the international construction domain. This paper focuses on developing and testing a 'risk-based go/no-go decision-making model' for contractors who wish to expand into international construction markets. The go/no-go decision model applies the cross-impact analysis (CIA) method to assess the various uncertainties associated with international construction. This research draws significant findings regarding the benefits of this go/no-go decision model from experimental studies involving 56 participants.

Keywords: International projects, risk analysis, risk-based entry decision model, cross-impact analysis (CIA), experimental case studies

Introduction

The globalization of international construction markets provides tremendous opportunities for contractors to expand into new foreign markets by allowing local firms to compete internationally (CII, 1993; *ENR*, 1997). However, entry decisions for international construction markets are difficult, due to the uncertainties and complexities associated with the international construction domain. International projects involve not only the uncertainties that arise in domestic construction projects, but also those from the complex risks that are particular to international transactions (Lee and Walters, 1989; Hill International, 1995).

Despite the risky nature and complexity of these entry decisions, most construction firms have entered international markets based on personal intuition or previous experience, both of which are easily influenced by uncertainties and biases (Messner, 1994). Moreover, existing decision tools and methods to evaluate international construction projects are incomplete and rudimentary.

In the context of doing business successfully in the globalizing construction markets, construction firms need reliable risk analysis and decision making tools to make consistent strategic go/no-go entry decisions. The fundamental goal of this paper is to introduce a risk-based, market entry decision (go/no-go) model designed to help contractors make better market entry decisions for international projects. The remainder of this paper focuses on four questions.

1. What are the characteristics of go/no-go decisions for international construction projects?
2. What are the essential elements of go/no-go decisions?
3. How should one formalize a market entry decision procedure?
4. Once formalized, does a procedure enhance market entry decision making?

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Characteristics of go/no-go decisions

Globalization pressures have created more opportunities for contractors to enter international construction markets. According to Han (1999), the potential international markets accessible to foreign firms due to globalization of the industry total approximately US$ 428 billion.

However, international projects manifest more risks and complexity than do domestic projects. For example, international construction is very sensitive to regional conditions such as currency devaluation, currency exchange restrictions, cultural differences, or unstable laws or regulations. A number of authors have described the risks specific to international construction projects (Ashley and Bonner, 1987; Lee and Walters, 1989; Demacopoulos, 1989; Messner, 1994; Hill International, 1995; Kalayjian, 2000). The classification displayed in Figure 1 partitions international construction risks into five categories: political risks, economic risks, cultural/legal risks, technical risks and other special risks related to international construction. The variety of these risks suggests the need for a formal methodology to incorporate the risks into a go/no-go decision.

According to *Engineering News Record* (*ENR*, 1995–1998), international construction projects are more risky but more profitable than domestic projects. Almost 15% of companies among the 'top 225 global contractors' have sustained losses on their international projects, whereas they sustained losses on only 10% of their domestic projects. However, the average profit from foreign work among these 'top 225 global contractors' was 9.34%, whereas that from domestic projects was 7.65% during the period 1994–1997. This implies that international construction contractors assume higher risks, but receive higher returns for their efforts.

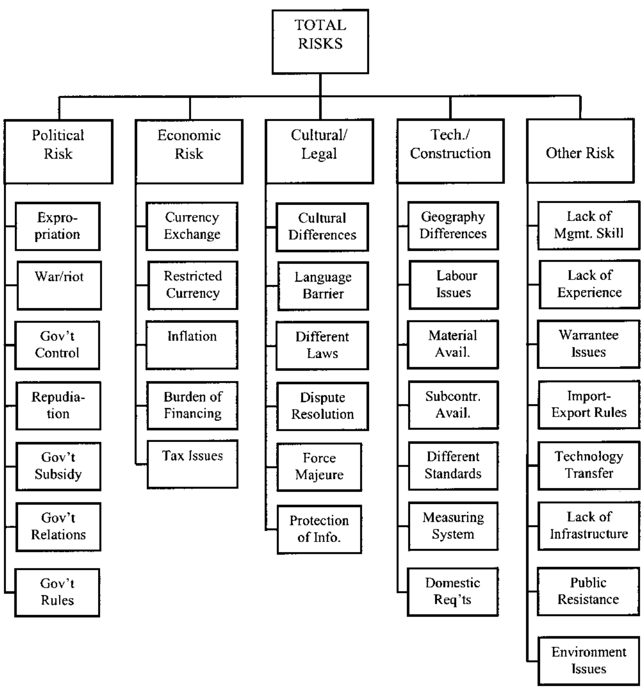

Figure 1 Breakdown structure of risks (revised from several sources including Ashley and Bonner, 1987)

According to MacCrimmon and Wehrung (1986), decision-makers are more risk averse in opportunity situations than in threat situations. As a consequence, contractors are less self-assured regarding go/no-go decisions for international projects than for doing work in domestic markets. Perhaps this explains why, in contrast to the globalization trend, only 19% of the current 'top 400 US contractors' actively seek and conduct international contracts (*ENR*, 1998). In particular, small and medium size firms, those that ranked between 100 and 400 among the 'top 400 US contractors', rarely participate in international construction markets. Because small and medium size firms are less likely to enter culturally distant markets, these firms are forced to seek low-risk, low-growth alternatives.

In addition to its risky nature, entering international construction markets is a highly integrated, complex decision. Market entry decisions consist of three sequential stages: (1) identification of countries that are favourable in which to do business; (2) selection of candidate projects within a candidate country; and (3) determination of whether to 'go or not to go' on a specific project opportunity. The complex, sequential nature of entry decisions makes the decision tools and methods for evaluating international construction opportunities difficult.

Elements of go/no-go decisions

A variety of information must be integrated in a comprehensive go/no-go decision model. Country conditions, project bid conditions and alternative project risk reduction strategies affect the likely project outcomes.

Country conditions and bid requirements

Country conditions are external variables that determine the initial circumstances of a particular project, such as political, economic or cultural conditions. Bid conditions are based on the bidding documents or the results of the initial negotiations between the owner and contractor. Typically, items that are subject to early determination include:

1. payment methods (US dollars, local currency),
2. currency exchange rate applied to a contract (fixed, variable),
3. payment term (monthly or quarterly),
4. applicable contract law (international standard contract, local rules),
5. contract languages (English, local),
6. dispute resolution process (court selection, forum, etc.),
7. tax reduction/exemption conditions (tariff, income tax, etc.), and
8. contractor financing requirements (ex, paid by owner after completion).

Risk reduction strategies

Many of the risks inherent in international construction can be mitigated or avoided by adoption of appropriate project execution strategies. A strategic decision can be defined as an act or choice between a set of feasible and available action courses, tending to improve the organization's goals (Messner, 1994). As an example, if the firm has sufficient resources and the technological ability to perform the project, but the project conditions are much riskier than normal, the firm could choose to negotiate a favourable dispute resolution process. Table 1 shows representative strategies designed to improve the firm's capacity to perform or to improve a project's particular conditions.

Multi-criteria outcomes

Traditionally, a go/no-go decision is viewed as focusing on maximizing profit as a sole consideration. However, according to several researchers, the underlying decision foundation is not totally profit-oriented, but is affected by a multi-attributed set of decision criteria (Ahmad, 1990). In addition to profit, companies often pursue projects based on multi-criteria outcomes, such as gaining future markets, their need for work, developing new relationships, etc. Therefore, the go/no-go decision includes multiple outcome variables.

In this problem domain, we conceptualize the go/no-go decision as one that is decided based primarily on a project profit criterion. If a project fails to satisfy the profitability criterion, other potential benefits of pursuing the project are considered, as shown in Figure 2. In this process, the decision-maker sets an absolute goal on 'expected project profitability' above which the decision is 'definitely go'. The decision-maker also sets a lower profitability limit to fix the 'definitely no-go' decision. If project profitability lies between these profitability limits, the decision is made by considering both 'project profitability' and 'other project benefits'.

Table 1 Typical decision strategies for international construction (revised from Messner, 1994)

Stages	Examples of initial conditions/ decision strategies
'Go' decision strategies:	– Develop a new organization (joint venture, subcontracting with local firm) to obtain competitive advantages and to perform project successfully.
These strategies can be defined as an act of choices between a set of feasible and available action courses. The firm can choose these strategies to improve the organization's goals and project conditions.	– Expand the firm's resources (financial resources, human resources, and physical resources) to increase the firm's competitive advantages.
	– Facilitate a positive relationship between the owner / government and the firm in an effort to gain pivotal information to win a contract and mitigate the owner's interventions.
	– Establish market analysis and a project feasibility study to evaluate market conditions and project soundness.
The final negotiation strategies:	– Negotiate payment methods (US dollars, local currency) to avoid severe fluctuations in the exchange rate.
These strategies can be followed after being selected as possible bidders and before signing contracts. The contractor can negotiate with the owner regarding the initial conditions in order to get the more favourable conditions to proceed the project.	– Negotiate applicable contract law (international standard contract, local rules) to mitigate legal / cultural variances.
	– Negotiate the processes for dispute resolution (court / forum selection, alternate dispute resolution procedure, etc.)
	– Negotiate tax reduction / exempt conditions to lessen heavy tax burden
	– Negotiate financing requirements to mitigate excessive financial burden.

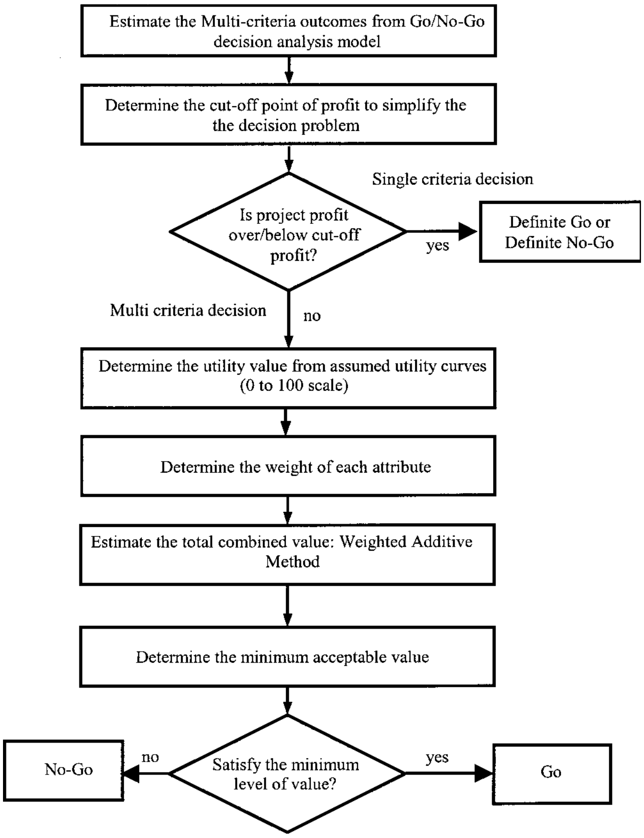

Figure 2 Go/no-go decision process model

Formalizing the go/no-go model

There are many approaches to dealing with uncertainties in risk/decision analysis. Historically, the mathematical theory of probability is the most widely used uncertainty-reasoning tool. In addition to probability theory, there are other numerical calculi for the explicit representation of uncertainty, or techniques to manage uncertainty using logic or other symbolic formalism (Shafer and Pearl, 1990). This section compares the advantages and disadvantages of several common uncertainty reasoning tools as suggested by various authors (Cooper and Chapman, 1987; Diekmann *et al.*, 1988; Flanagan and Norman, 1993; Takayuki, 1994).

Current go/no-go approaches

Monetary/financial approach

Perhaps the most common methods for evaluating potential projects are designed to measure a project's financial characteristics, such as net present value (NPV), internal rate of return (IRR), break-even point, or cash flow. Although project financial analysis can provide speedy evaluation of a project, it cannot address all risk factors that are critical to a go or no-go decision (Ock, 1998). Traditional financial analysis is not an appropriate method for evaluating project feasibility when large and long term systems are married to uncertainties, because it cannot reflect the risk-based contingencies in the evaluation of strategic alternatives (de Neufville, 1990).

Probability theory

Frequently, probability theory is used where the decision is best represented as a sequence of related decisions and variables. Also, it is used to recast a complex decision sequence into several smaller related decisions. However, too much complexity in the form of correlated random variables can make this approach difficult in the case of complex decision problems.

Neural network / knowledge map

A neural network technique is a statistical learning algorithm, drawn from the field of artificial intelligence. It adopts non-parametric regression estimates made up of a number of interconnected, processing elements between input and output data. It is superior in mean convergence, but highly sensitive to the data set and training set. Therefore the result may not be sufficiently robust when used to predict output using newly observed data.

Influence diagrams

Influence diagrams are good at modelling the conditional probability relationship among random variables. They are more versatile than a decision tree and able to handle a large amount of model complexity. They are used for both model formulation and analysis, and thus serve both quantitative and qualitative purposes. However, influence diagrams require a detailed accurate representation of the probabilistic relationships among the decision variables.

Cross-impact analysis (CIA) method

Most of these traditional uncertainty-reasoning techniques require significant data collection, formulation of mathematical representations, assessment of conditional probabilities, or definition of probability density functions. However, uncertainties involved in international construction are difficult to assess using traditional tools such as probability theory and influence diagrams, because the data required for the model are highly judgmental, and either unavailable or very expensive to collect. Additionally, the go/no-go decision model entails a dynamic multi-stage decision process and a highly complicated relationship among the risk variables, so that it is very hard to assess the accurate probabilistic relationship between variables. For these reasons, all of the more traditional uncertainty reasoning methods were rejected for this application, and the cross-impact analysis (CIA) method was adopted for this go/no-go application.

The CIA method is a technique specifically designed to predict future events by capturing the interactions among the variables of the model. The original CIA method was developed by Gordon and Hayward (1968), in an attempt to take into account impacts among separate future events. In the CIA method, each variable is described by an initial probability, and the interconnections between these variables are modelled by cross-impact relationships. The basic cross-impact relationship between two variables describes how the initial probability of a conditional variable will be inhibited or enhanced if a conditioning variable occurs.

Originally, the computational mechanism for determining the impact of a conditioning variable on the posterior probability of a conditional variable was expressed by the quadratic relationship equation (Gordon and Hayward, 1968). Subsequently, researchers have proposed alternative methods for calculating the posterior probabilities. For example, Honton *et al.* (1985) adopted a categorical approach to estimate the posterior probability by specifying for the direction and strength of the intervariable impacts. An index number between −3 and +3 is used to express the cross-impact relationship, and then this number is used to calculate the impact using an analytical expression with a more rigorous mathematical formulation. Alarcon (1992) developed the concept of cross-impact relation patterns in order to simplify the knowledge acquisition demands of the traditional CIA methods. The cross-impact relation patterns between variable pairs are classified into: (1) SIG−, significantly in the opposite direction; (2) MOD–, moderately in the opposite direction; (3) SLI−, slightly in the opposite direction; (4) SIG+, significantly in the same direction; (5) MOD+, moderately in the same direction; and (6) SLI+, slightly in the same direction.

Based on the CIA relation patterns, the posterior probability can be predicted throughout the series of analytical processes (a brief description of CIA analysis methodology is presented in Appendix A). The general steps for the CIA method are: (1) define variables to be included in the analysis; (2) determine the initial probability of each variable; (3) judge the CIA relations for each variable pair; (4) repeatedly perform the cross-impact calculations by Monte Carlo simulation; and (5) evaluate the posterior probability to forecast future events.

The CIA method is a powerful technique for dealing with ill-defined uncertainty. In contrast to other uncertainty reasoning tools, the CIA method places relatively minor data demands on the decision-maker. The CIA method generates various scenarios that are used to analyse the sensitivity of variables, and produces multi-criteria outputs that include mean values and probabilistic distribution shape. Accordingly, the CIA method is more effective than other tools in the following circumstances, which exactly match this problem domain.

- The model involves very complex and unclear relationships among variables; the CIA method is excellent at integrating political, economic, and technological factors.
- The data required for the model are scarce, unavailable, or very expensive to collect, and it is easier to elicit 'subjective' probability information using the CIA categorical approach than a standard probability approach.
- The model involves various possible decision alternatives. The CIA method can show the results of various possible decision alternatives by using scenario analysis when the decision-maker cannot ascertain that a single solution is optimal.

A CIA-based go/no-go decision model

An ideal go/no-go model incorporates all of the important project, bid and country conditions. Additionally, it allows the decision-maker to evaluate alternative project strategies and it provides for evaluation of all of the multiple outcomes of the project, both profit and non-monetary benefits. A decision model using the CIA framework was developed that satisfies all of these requirements. The variables included in the model were defined through an extensive literature review, multiple expert interviews and a preliminary case study (Han, 1999).

CIA cause–effect relationships model

The CIA method encapsulates the knowledge about a go/no-go decision into a cause–effect relationship map. This map provides both a classification of the variables in the model and their inter-relationships, and it provides a computational basis for decision making (Figure 3). The CIA model includes 32 variables along with their CIA relationships. The CIA relationships are not fixed: they are flexibly modifiable according to the country conditions, project conditions, and the decision-maker's context specific knowledge. It helps to understand this very complex model by conceptualizing the model's variables as belonging to one of five groups, as shown in Figure 4.

One set of variables, 'country conditions', represents each country's unique *a priori* atmosphere for conducting trade. The country conditions are cultural and legal conditions, political conditions, economic condi-

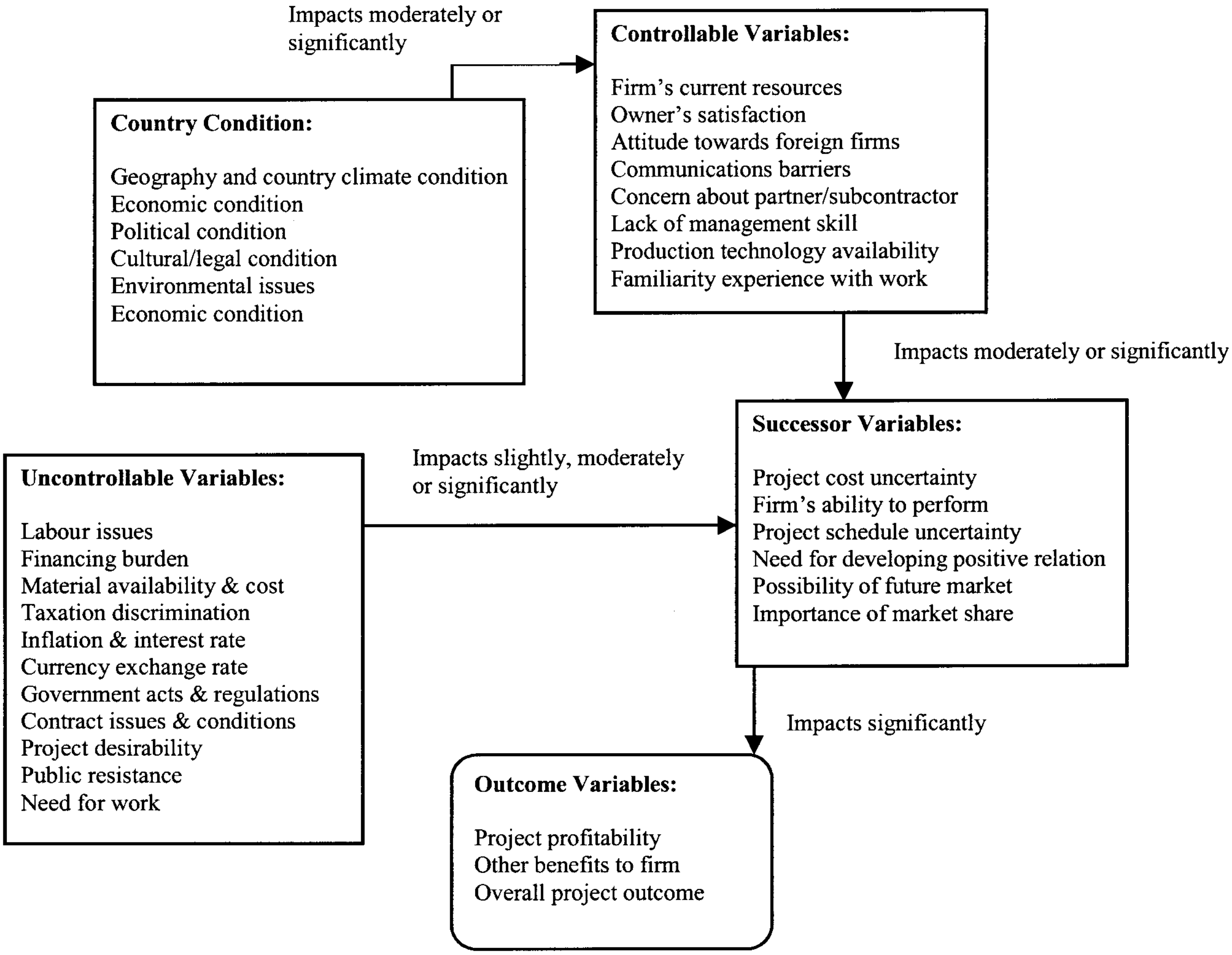

Figure 3 Cross-impact analysis cause–effect relation map

tions, geography and climate conditions and environmental conditions. Each of these overlying conditions impacts (in the cross-impact sense) several other variables. Country conditions are relatively fixed for any given country; however, over the lifecycle of a project the economic, cultural and political conditions can change, and therefore they are treated as being uncertain.

A second set of variables represents the construction contractor's decision strategies. Specifically, the contractor's resources, experience, management skill, owner relationships and strategic partnerships are defined as strategic variables. Contractor's strategic variables are presumed to be controllable in that a contractor can hire more talented or experienced people, change its strategic alliances or commit more resources.

The third and largest set of variables is those that are impacted by either the country condition or decision strategies, and these are called intermediate variables. The intermediate variables are divided into those that are impacted by the contractor decision strategies (the controllable variables) and those that are not controllable variables. These variables provide the means to propagate the impacts (indeed the cross-impacts) of the initial conditions (country condition and contractor's decision strategies) to the model results.

The fourth type of variable reflects the probable outcomes of the project, i.e. a successor variable set for producing the final results. There are three project outcomes, namely, project cost uncertainty, project schedule uncertainty and contractor's ability to perform the project. In addition, there are three corporate outcomes, namely, potential for future work, importance of developing market share, and importance of the developing relationship with the client.

The fifth set of variables is the outcome variables on the basis of which the go/no-go decision is made. There are two outcome variables, the 'project profitability' outcome and the 'other benefits' outcome. The project profitability outcome is a combination of the previously mentioned successor variables (cost, schedule, and

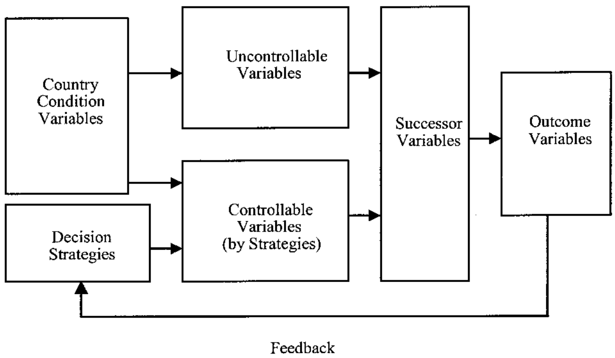

Figure 4 Conceptual elements of go/no-go decision

ability to perform). The other benefits outcome is a combination of the previously mentioned corporate outcomes (client relationship, future work and market share).

In practice, one employs the model by defining the initial country conditions, the initial contractor decision strategies and the appropriate cross-impact relationships for the model. Using the cross-impact method, the initial and strategic conditions are propagated through the model to the outcome variables. The value of the outcome variables provides the normative metric on the basis of which the go/no-go decision is made.

Designing project strategies

The impact of alternative decision strategies that could be used to mitigate or avoid a risk can be evaluated analytically using the CIA method. Figure 5 is a matrix showing various project risk reduction strategies. The CIA model can be used to assess the impact of these alternatives on the project outcomes. The tick mark represents the possible impact of the decision strategies on the controllable variables. For example, if a contractor selects 'alliance strategies' to develop a new organization, they can partially or fully control certain types of risk variable (i.e. partner/subcontractor's concern, lack of management skill, production technology availability, and familiarity with work). To evaluate the effectiveness of an alliance strategy the decision-maker would suitably alter the strength relationship of the CIA model. Based on the trial results, a decision-maker can evaluate which alternative strategies are the most effective in improving project outcomes.

Go-Decision Strategies					Possible Impact on Strategy Condition Variables							
Develop organization (Alliance •, Solo)	Facilitate firm's relationship to owner (Yes •, No)	Establish market analysis and feasibility study (Yes •, No)	Expanding firm's resources (Yes •, No)	Subcontract with local firms (Yes •, No)	Partner/subcontractor concerns [skill, experience]	Attitude toward foreign firms	Lack of management skill	Communication barriers	Production technology availability	Familiarity, experience with work	Owner/client satisfaction	Firm's current resources
•	•	•	•	•	√	√	√	√	√	√	√	√
•					√		√		√	√		√
	•					√					√	
		•										
			•									√
				•	√	√		√			√	

Figure 5 Decision strategies matrix. Each row shows the different decision alternatives combined. A dot indicates that the decision option is selected and a tick represents the possible impact of decision alternatives on the controllable strategy condition variables

Model test and results

Testing the CIA model

A test of a CIA-based go/no-go model was conducted to validate the anticipated benefits of the model. In this test the value of the CIA model was measured based on 'decision quality'. Decision quality is a function of the independent variable decision tools, decision-makers' international experience, and project conditions. The following equation implies the research question of whether independent variables (Xi) can cause the dependent variable (Y) in a hypothesized way.

$$Y(\text{decision quality}) = F[X_1(\text{decision tools}), X_2(\text{experiences}), X_3(\text{projects})]$$

56 subjects from three different experience backgrounds (19 novice graduate students, 18 inexperienced industry persons, and 19 experienced industry persons) participated in this study. These three groups were divided equally into two subgroups comprising an 'intuition group' and a 'CIA-based go/no-go model group'. As indicated by the subgroup names, the intuition group used their intuition combined with rudimentary financial analysis to make the go/no-go decision. The CIA group used the CIA-based model to make the go/no-go decisions.

Experimental designs can be categorized broadly into three types: pre-experimentation, true experimentation, and quasi-experimentation. Additionally, each experimental design type is categorized further into: (1) within group or between group; (2) one group or multiple group; and (3) before–after or only–after test (Malhotra, 1993; Martin, 1996; Garziano and Raulin, 1997).

For this paper, a 'randomized multiple-groups only–after design (between group) was selected for the experimental case study design in order to: (1) avoid the transfer and practice effect by assigning one participant for only one level, i.e., either intuition or the go/no-go decision model; (2) minimize the differences between groups by matching novice graduate students, inexperienced and experienced industry groups; and (3) hide the research hypothesis in order to avoid a predisposition toward a desirable response. (The participants from different groups were assigned randomly to the experimental test, i.e. randomized multiple-groups, and each participant was tested at only one level, so that the testing effect could be eliminated (only–after between groups).) Table 2 shows the framework of experimental case study format.

One of three hypothetical, international projects was assigned at random and equally to each participant in an attempt to prove the research hypothesis regardless of the project types and participants' experience. These case projects were designed to provide various country and project conditions, such as a power plant in Laos, a housing project in India and a highway project in China. Based on a consensus of prior expert assessment and independent risk and economic analyses, the Chinese project was assessed to be a 'good' candidate project; the Laos project a 'moderate' candidate; and the Indian project a 'poor' candidate. The suggested correct decisions were veiled from all participants in order to avoid any potential biases. The details of each project are shown in Appendix B.

Each study participant was asked to make a go/no-go decision and asked to respond to several questions that measured how well the different decision tools affected: (1) decision correctness (percentage of right decision); (2) decision confidence and reliability for their final decisions (qualitative rating scale from 1, not confident, to 7, very confident); (3) decision difficulties in making judgments in uncertain environments (qualitative rating scale from 1, not difficult, to 7, very difficult); (4) decision formulation for understanding a complex problem domain (qualitative rating scale from 1, not very helpful, to 7, very helpful); and (5) decision consistency (percentage of decisions that changed when the experiment was repeated at a later date).

Table 2 Experimental case study design[a]

Novice group (graduate students)			
EG_1	Random	Go/no-go model	O_1
CG_1	Random	Intuition	O_2
Inexperienced industry group			
EG_2	Random	Go/no-go model	O_3
CG_2	Random	Intuition	O_4
Experienced industry group			
EG_3	Random	Go/no-go model	O_5
CG_3	Random	Intuition	O_6

[a]Notes: EG*i*, experimental group that makes decision using the go/no-go model; CG*i*, control group that makes decision by intuition; Random, random selection and assignment of participants and project cases; and O*i*, measurement of dependent variable (decision quality).

Research findings

Table 3 summarizes the experimental findings. To evaluate the research hypotheses, statistical methods were used to analyse the data, so the results and conclusions are objective rather than judgmental in nature. Comparisons of mean/standard deviation values and an analysis of variance (ANOVA) were performed.

As shown in Table 3, the intuition-based decision-makers were confounded by the complexity of the circumstances. As a result, only 70% of the decisions made by the intuition group were correct. By contrast, 96.2% of the decisions made by the CIA model group were correct. There were numerous factors that caused the subjects to make incorrect decisions. In the case of the intuition group, the go/no-go decision was influenced by the complexities and several biases, such as:

(1) decision-makers focused on only the negative decision factors like unfavourable political/economic risks, government control and competitive bid type, rather than other various positive aspects;
(2) decision-makers ignored some relevant factors such as possibility of future market and firm's need for entering overseas markets;
(3) decision-makers simply counted the number of risks; and
(4) decision-makers exhibited an extremely risk-averse attitude.

Interestingly, most of the type I errors ('go' decisions for bad or moderate projects) were made by the novice group, while type II errors ('no-go' decisions for good projects) were made by industry participants focusing on negative factors. In addition to decision correctness, the CIA group experienced higher levels of decision quality than did the intuition-based decision making group. Decision quality was measured by: (1) higher decision confidence; (2) less difficulty in arriving at a decision; (3) higher degree of guidance from the model in formulating a decision; and (4) better long term consistency in their decisions.

Another distinctive finding is that the go/no-go decision model was more helpful for novices and the inexperienced group than for the experienced group (Table 4). For example, although the go/no-go decision model increased the decision correctness for all groups, it was more helpful for novices (67% increase) and the

Table 3 Results of experimental test

Categories	Intuition-based (30 subjects)[a]	CIA-based model (26 subjects)	Improvement	ANOVA
Correctness (%) [b]	70%	96.2%	Increased 37%	Significant at 94.5% [c]
Confidence (1–7)	5.4	5.9	Enhanced 10%	99%
Difficulty (1–7)	2.83	2.19	Reduced 23%	97%
Formulation (1–7)	2.97	5.2	Assisted 75%	95%
Consistency (%)	30% changed their previous decisions	Virtually 0% changed their previous decisions	Increased 30%	–

[a]The participants consisted of 19 graduate students and 37 industry decision makers (18 subjects had less experience in international construction, while 19 were experienced).

[b]The correctness of the decisions was counted as the number of right decisions out of the subtotal of each group. The decision confidence level was measured using a qualitative index number ranging from 1 (not confident) to 7 (very confident), the decision difficulty ranged from 1 (not difficult) to 7 (very difficult), and the decision formulation ranged from 1 (not very helpful) to 7 (very helpful).

[c]The combined effect of the test is significant at about 94.5%. It indicates highly significant differences in the decision correctness among each group with different decision tools (intuition and CIA-based model groups).

inexperienced group (33% increase) than for the experienced group (22% increase). These results support the hypothesis that a model can assist contractors, particularly inexperienced firms, who wish to expand into overseas markets.

Conclusions

The go/no-go decision model incorporates a number of useful features. First, it includes a wide variety of factors (variables) that are important to go/no-go decisions. Second, it provides a rich context for modelling the relationships among decision variables. Third, it allows the decision-maker to include uncertainty in the decision formulation and to evaluate the effect of uncertainty on project desirability. Fourth, the model allows the decision-maker to define a multi-dimensioned project outcome variable. Finally, the model allows the decision-maker to evaluate alternative decision strategies.

A variety of significant findings are identified from the validation tests. First, the model consistently improved decision quality in terms of increasing decision correctness, enhancing decision confidence, reducing decision difficulties, assisting with the formulation of complex decision problems, and increasing decision consistency. Second, although the go/no-go model increased the decision quality for all groups, it was more helpful for novices and inexperienced group than for the experienced group. Third, both novices and industry participants repeatedly showed that go/no-go decisions based on intuition were influenced by the complexity of uncertain information and several biases. Fourth, decision-makers felt less confident and more challenged regarding case 3 (China, good project) and case 1(Laos, moderate project) than with their decision for case 2 (India, poor project). Consequently, most of the intuition subjects assigned case 2 made perfect decisions, while approximately 42% of intuition participants assigned case 1 and case 3 made wrong decisions. Fifth, industry participants were more risk averse than novices. They indicated higher values in the project profitability for ‘definitely go’. They also required a higher degree of other benefits from the project for a ‘go’ decision. Finally, the Korean industry participants demonstrated more risk-taking attitudes than those of the US participants.

Table 4 Improvement of decision quality of each group

Categories	Novices (19 subjects)	Inexperienced (18 subjects)	Experienced (19 subjects)
Correctness	Increased 67%	Increased 33%	Increased 22%
Confidence	Enhanced 16%	Enhanced 11%	Enhanced 3%
Difficulty	Decreased 38%	Decreased 24%	No change
Formulation	Assisted 77%	Assisted 75%	Assisted 70%

Based on the test results, the CIA-based go/no-go model is worth promoting as an advanced analytical tool for contractors, especially for small and medium size firms planning expansion into international construction markets. Future research will concentrate on the extension of the current go/no-go model for other entry decision stages, such as country screening tools and candidate project selection tools within a country.

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Appendix A: Description of the CIA methodology

Suppose that two variables A and B in Figure A 1 consist of two possible event states. Each variable has an initial probability as shown in Table A 1. In this simple explanation of CIA computation, the variable A influences another variable B. Therefore, it is assumed that the cross-impact matrix is judged as shown in Table A 2.

The next step is to calculate the posterior probability of variable B. Suppose that event A_1 were to occur as a result of Monte Carlo random sampling,

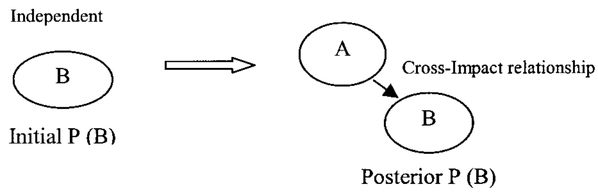

Figure A 1 Simple example of two variables

Table A1 Information on variables

Variable	Events	Initial probability
A	A1	0.5
	A2	0.5
B	B1	0.4
	B2	0.6

Table A2 Cross-impact relationship table[a]

		A		*B*	
		A_1	A_2	B_1	B_2
A	A_1	—	—	0	0
	A_2	—	—	0	0
B	B_1	3	3	—	—
	B_2	−3	3	—	—

[a]If event A_1 occur, events B_1 and B_2 will be impacted significantly in the positive and negative directions, respectively.

3 : Significantly increase
2 : Moderately increase
1 : Slightly increase
0 : No effect

the probability of variable B is adjusted according to the following analytical formula justified by Honton *et al.* (1985).

$$\text{Posterior } P_n = \frac{\text{Initial } P_n \times \text{CV}}{1 - \text{Initial } P_n = (\text{Initial } P_n \times \text{CV}}$$

where the coefficient value CV is

$$\text{CV} = \begin{cases} |\text{Cross-impact index}| + 1 & \text{if index} \geqslant 0 \\ \dfrac{1}{|\text{Cross-impact index}| + 1} & \text{if index} < 0 \end{cases}$$

$$\text{Posterior } P(B_1) = \frac{0.4 \times 4}{1 - 0.4 + (0.4 \times 4)} = 0.73$$

$$\text{Posterior } P(B_2) = \frac{0.6 \times 0.25}{1 - 0.6 + (0.6 \times 0.25)} = 0.73$$

If event A_2 were to occur, the probability of variable B is influenced in a similar way. The above steps are repeated a large number of times until an acceptable error is reached (Monte Carlo simulation). In the above example, variables A and B are both described by the initial probabilities. The posterior probability of variable B is said to be the 'posterior probability (after-fact)' due to the cross-impact effect of variable A. Instead of conditional relationships between variables, the cross-impact matrix table describes the relationship between variables.

Appendix B: Case design of three project conditions

Three different cases were designed to reflect the reality of international construction projects. They were randomly and equally assigned to the participants. The real project conditions were modified to form good, moderate, and poor projects in order to manipulate the decision making conditions and measure the decision quality related to various project conditions. These three cases have different features regarding the boundary conditions and the project related information. The following is a brief overview of three cases (Table B 1).

Table B 1 Conditions for hypothetical projects

Items	Case 1	Case 2	Case 3
Owner	Laos government	Indian government	Chinese government
Project type	Power plant	Housing project	Highway project
Project size	Approx. US $100 million	Approx. US $300 million	Approx. US $500 million
Bidding system	Open competitive bid	Open competitive bid	Open competitive bid
Total duration	48 months with relatively strict completion penalties	60 months with strict penalties	48 months with lenient completion penalties
Contract type	Lump sum with escalation clauses	Lump sum (fixed fee)	Unit price
Payment methods	50% in US dollars 50 % in local currency	100% local currency	70% in US dollars 30 % in local currency
Timing of payments	Normally monthly base	Normally quarterly base	Normally monthly base
Force majeure risks	Partly assumed by Laos government	Partly assumed by Indian government	Assumed by Chinese government
Applicable contract law	International standard contract written in both local and English.	Local standard contract written in local language	International standard contract written in both local and English
Tax reduction/ exempt conditions	Partly provided based on international trade agreements	Same	Same
Fund source	Financed by Asia Development Bank	Indian government	Financed by World Bank
Prior project profit	Anticipates average prior profit as 4%, the best case and the worst case are 20% gain and 15% loss.	Anticipates average prior profit as 3%, the best case and the worst case are 20% gain and 15% loss.	Anticipates average prior profit as 5%, the best case and the worst case are 20% gain and 15% loss.
Future markets	Expected other huge project around this site	Same	Same
Firm's goal	Enter new overseas markets with due precautions	Same	Same
Firm's international experience	Only domestic	Only domestic	Domestic and international, but not involved in China
Assumed winning probability	25%	20%	30%
Project conditions	Moderate	Poor	Good
– Overall country risks	Very high	Very high	Intermediate
– Overall project risks	Intermediate	High	Low
Suggested correct decisions [a]	No-go or indeterminate	No-go	Go

[a]Suggested correct decisions were arrived at based on a prior expert's assessment from a qualitative standpoint (comparison of how various attractive and unfavourable factors are relevant to the project conditions), independent risk and economic analyses (quantitative comparison of influence diagram), and a prior evaluation from a CIA-based model.