An analytic hierarchy process based model for risk and opportunity assessment of international construction projects

Irem Dikmen and M. Talat Birgonul

Abstract: Risk assessment of international projects is a complicated task because of the sensitivity of project success related to country specific risks as well as project risks. Decision makers face the difficulty of weighing project opportunities against risks and determining attractiveness of projects while giving bidding decisions. The aim of this paper is to propose a methodology for risk and opportunity assessment of international projects. The proposed model uses an analytic hierarchy process for calculation of risk and opportunity ratings. A risk breakdown structure, specific to international construction projects, is proposed as well as a list of factors that affect the ability of construction companies to manage risk. An application of the proposed methodology is demonstrated by using real data supplied by a construction company that is experienced in international markets. Ranking of project options is made according to the opportunity and risk ratings that are calculated by using the proposed methodology based on the judgments of company professionals.

Key words: international construction, risk assessment, analytic hierarchy process.

Résumé : L'évaluation des risques des projets internationaux est une tâche compliquée en raison de la sensibilité de la réussite du projet par rapport aux risques spécifiques du pays et aux risques du projet. Les décideurs font face à la difficulté de peser les bénéfices du projet par rapport aux risques et de déterminer l'attrait des projets tout en établissant les appels d'offre. Le but du présent article est de proposer une méthode pour l'évaluation des risques et des occasions des projets internationaux. Le modèle proposé utilise le processus de hiérarchie analytique pour calculer les cotes de risques et d'occasions. Une ventilation des risques spécifiques aux projets de construction internationaux est proposée, de même qu'une liste de facteurs qui affectent la capacité des compagnies de construction à gérer les risques. Une application de la méthode proposée est démontrée en utilisant de vraies données fournies par une compagnie de construction ayant l'expérience des marchés internationaux. Les options des projets sont classées selon les cotes de risques et d'occasions calculées en utilisant la méthode proposée basée sur les jugements des professionnels de cette compagnie.

Mots clés : construction internationale, évaluation des risques, processus de hiérarchie analytique.

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Risk and opportunity assessment of international construction projects

While giving bid/no-bid decisions, decision makers usually try to assess the attractiveness of alternative projects by estimating expected opportunities as well as potential risks that will be retained by the company. Opportunities can be measured by expected performance of the project in satisfying the company objectives, whereas risk assessment requires identification of risk factors and quantification of risk impacts on project success. Thus, while giving bidding decisions in international markets the major task of the decision maker is to construct a conceptual model that integrates project, market, and country level risks with the opportunities. Constructing a conceptual model is not an easy task, as international projects manifest more uncertainty than domestic projects. A number of authors have described risks specific to international construction (Ashley and Bonner 1987; Sloan and Weisberg 1997; Jaselskis and Talukhaba 1998; Hastak and Shaked 2000; Han and Diekmann 2001; Levitt et al. 2004). Impacts of political risks (Ashley and Bonner 1987), cultural difference among multinational project participants (Chan and Tse 2003), regulatory restrictions, contractual arrangements, and differences in standards (Chua et al. 2003) have been, especially, discussed for different countries and market conditions. To facilitate bidding decisions in overseas markets, different support tools are proposed within the construction management literature. However, most of the tools are used for quantification of risks, whereas opportunities are usually not covered. Han and Diekmann (2001) proposed a "risk-based go/no-go decision-making model", which uses the cross-impact analysis (CIA) method to assess various uncertainties associated with international construction. Hastak and Shaked (2000) de-

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veloped an analytic hierarchy process (AHP) based decision support tool to quantify risk rating of international construction projects. Dikmen and Birgonul (2004) proposed a neural network model to estimate attractiveness of international construction projects rather than assessing risks and opportunities separately. The aim of the current study is to propose a methodology for quantification of risks and opportunities in international projects so that the decision maker may consider both factors and give a reliable bidding decision. The proposed methodology may make it possible to rank international construction projects according to their risk and opportunity ratings and provide a sound platform for comparison of alternatives.

Objectives of the research

Gaps in the current state of knowledge and objectives of the research can be summarized as follows:

Gap 1 — Poor definition of risk and lack of a generic checklist for risks in overseas projects: When literature is investigated, it is clear that there are numerous risk checklists and risk breakdown structures proposed by different researchers (Hastak and Shaked 2000; Han and Diekmann 2001; Chua et al. 2003). The major drawback in some of these lists is inconsistency. The word risk may be used to imply source, consequence, or probability of occurrence of a negative event. When sources are mixed with consequences, it leads to a major inconsistency and wrong formulation of the risk model. For example, cost overrun or delay risk should be considered on a different platform than sources like inflation, technical risk, or changes in project scope. In this research, all the factors that may have an impact on the project success are defined as risk factors, and thus causes of poor performance and deviation from expected outcomes constitute major entries of the risk breakdown structure rather than the consequences. Thus, the first objective of this research can be stated as

- to propose a risk breakdown structure to facilitate identification of risk sources in international projects

A hierarchy, depicted in Fig. 1, has been defined to categorize risk sources that may emerge from project characteristics and country conditions. This risk breakdown structure includes all possible sources of risk in international projects. A decision maker may use this structure to further specify potential risk events and quantify their impacts on project success.

Gap 2 — Lack of systematic procedures to quantify both risk and opportunity in overseas projects: As previously mentioned, although there exist some risk analysis support tools proposed in the literature for international projects, usually risk and opportunity are not considered simultaneously. The major difference of the proposed methodology is an introduction of opportunity aspect into risk assessment. For this purpose, analytic hierarchy process (AHP), a multi-criteria decision-making tool where both attributes can be considered, is selected as the appropriate solution method. Therefore, the second objective of this research can be stated as

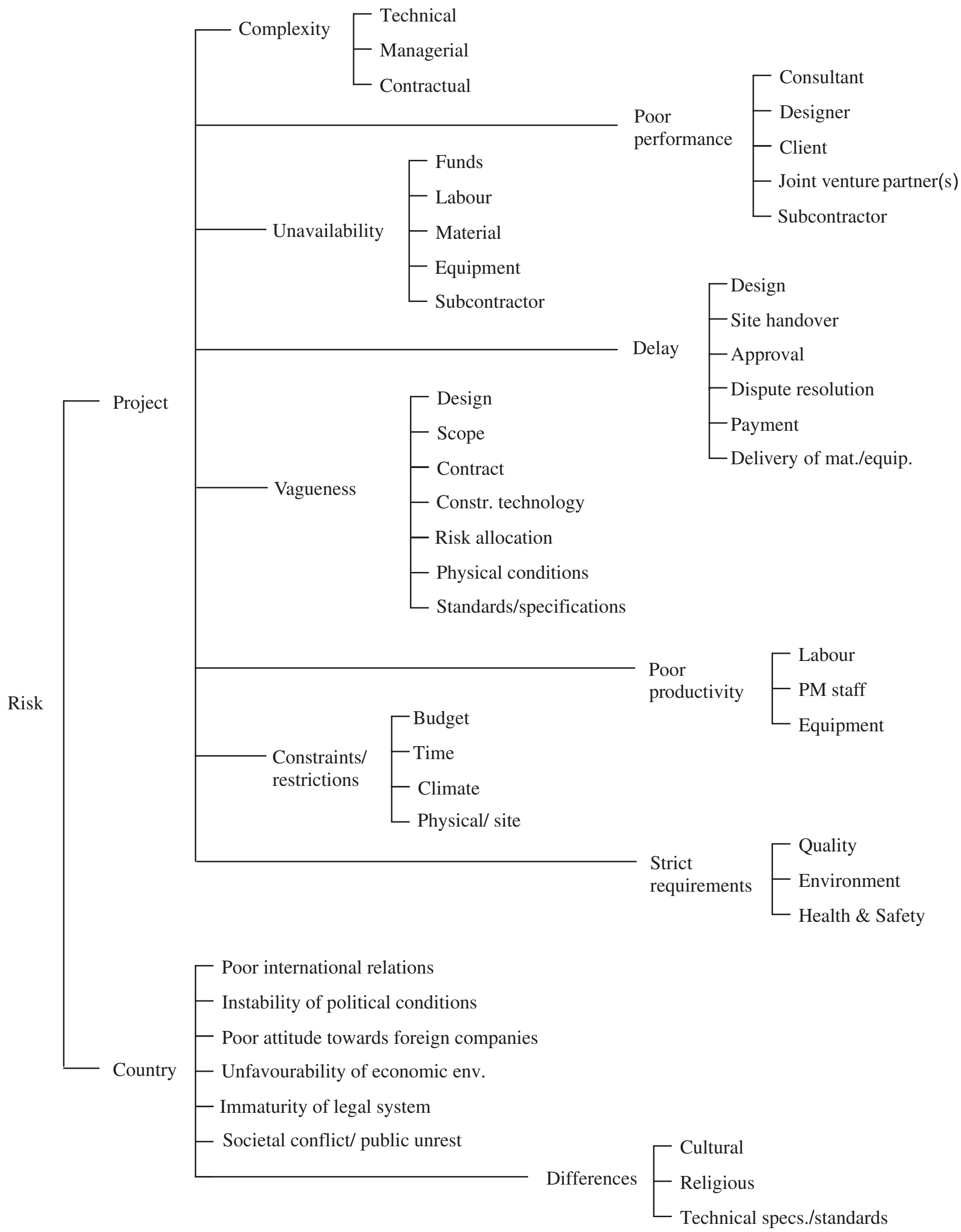
- to propose a methodology for assessment of both risk and opportunity in overseas projects and for ranking of projects

The fundamentals of AHP and differences of the proposed methodology are discussed in the next section.

Theoretical background and fundamentals of the proposed methodology

Analytic hierarchy process (AHP) is a multi-criteria decision-making technique proposed by Saaty in 1976. It is a comprehensive framework that is suitable for situations when people make multi-objective, multi-criterion, and multi-actor decisions with or without certainty for any number of alternatives. The AHP models a decision-making framework that assumes a unidirectional hierarchical relationship among decision levels. The top element of the hierarchy is the overall goal, and it decomposes to more specific attributes until a level of manageable decision criteria is met. It is a discrete measurement theory that derives scales of values from pairwise comparisons and from ratings (Saaty 2000). In AHP, paired comparison judgments from a fundamental scale of absolute numbers are entered in a reciprocal matrix. Their numerical values and corresponding intensities are 1 = equal, 3 = moderately dominant, 5 = strongly dominant, 7 = very strongly dominant, and 9 = extremely dominant, along with intermediate values for compromise and reciprocals for inverse judgments (Saaty 2004). From the comparison matrix, an absolute scale of relative values is obtained on normalization (by dividing each value by the sum of all the values). Thus, the major logic is to get relative measurement, derived from paired comparisons, rather than absolute measurement, which is obtained by using a constant scale. Since its introduction, numerous applications of AHP have been published in literature. Previously, Hastak and Shaked (2000) developed ICRAM-1, which is an international construction risk assessment model based on a revised version of AHP. In that model, authors identified risk factors, calculated importance of risk using the comparison procedure in the matrix format as in AHP, identified risk rating of each project by considering the impact of country and market level risks on the project, and finally quantified the overall risk rating by multiplying importance weights with the rating and adding them up. As an alternative method to AHP, simple multi-attribute rating technique (SMART) has also been used by many researchers as a risk rating tool (e.g., AbouRizk and Er 2004). The major difference between SMART and AHP is the comparison method used to evaluate performance of alternatives as well as importance weight associated with the attributes. In SMART, absolute measurement method is used where a physical scale is defined and values are assigned by using this scale; thus, value assigned to an element is unconditional and does not depend on measurements of other elements. However, in AHP, pairwise comparisons are carried out and values derived are conditional. The value derived for each element is relative to the other values it is compared with; thus, each time an element is compared with other elements, it may have a different value. In AHP, comparison matrices are constructed to carry out pairwise comparisons, and thus consistency ratios can be

Fig. 1. Risk breakdown structure for international construction projects.



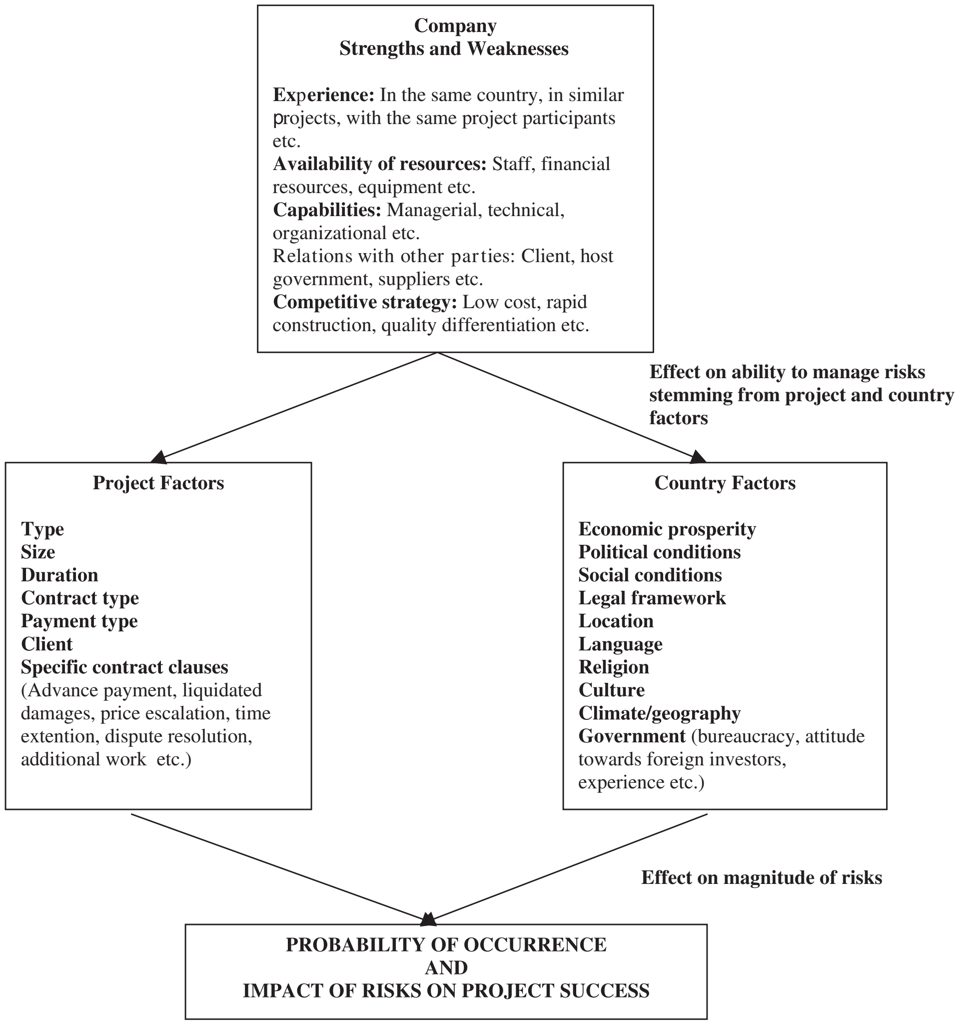
calculated as control measures so that the decision maker can understand whether the evaluations are consistent or not. Also, a user is not required to define a subjective scale and utility and (or) value curves that reflect preferences of the decision maker for different attributes. For more information about AHP, readers may refer to Saaty (2000).

The risk and opportunity rating procedure proposed in this paper uses the logic of AHP, that is, relative measurement rather than absolute measurement, but it has some differences from the classical AHP, which are explained below:

(1) The magnitude of risk can be defined as a function of its probability of occurrence and impact. In this research, as sources of risks are considered rather than the consequences, it is assumed that magnitude of a risk can be quantified if the following two factors can be assessed:

- *Impact on the project in case where a problem is caused by the given risk source*: For example, the level of impact on the project in case where a problem caused by the "poor performance of subcontractors" is questioned. The impacts may be delay of work, poor quality leading to extra cost of rework, etc. Thus, the decision maker should evaluate magnitude of an impact on the project success criteria, if problems occur because of a given source of risk.
- *Probability of occurrence of a problem as a result of the given risk source*: For example, the probability of occurrence of a problem due to poor performance of the subcontractors is investigated. The decision maker should consider the previous experiences with the subcontractor and if they have worked together be-

Fig. 2. Factors that affect risk level of an international project.



fore, the decision maker should evaluate the potential performance of the subcontractor by examining his strengths and weaknesses. Therefore, for each risk factor, a probability value should be assigned.

Finally, the magnitude of risk is determined by multiplying the relative impact with the relative probability of occurrence for each risk source defined in the risk breakdown structure and by adding them up to calculate an overall risk level of a project. Thus, instead of the importance weights and performance ratings as in AHP, impact and probability values are used in the proposed methodology, respectively. It should be reminded that, the calculated risk value is a relative value rather than an absolute value.

(2) However, while evaluating impact and probability of occurrence, usually the decision makers consider an implied factor, controllability, which is usually not considered in risk quantification formulas. If a risk factor is in reasonable control of a company, both the probability of occurrence of a problem and the potential impact may be assigned a lower rating. Thus, probability and impact values are neither constant for each project nor for each company; instead, they depend on many factors related to the capabilities of the firm, its experience in the market and in similar kind of projects, etc. Consequently, the following factors are considered in the proposed risk rating procedure:

- Factors that affect controllability (either by affecting the probability of occurrence of a problem or impact of a risk or both) as well as the risk sources have also been defined. These factors are specific to international construction projects, and they guide the decision maker during the risk rating process (Fig. 2).
- In many applications of AHP, it is assumed that weights remain constant and performance of each alternative is evaluated using the same weights. Although it is a valid concern for multi-criteria decision making problems where the preferences of the decision maker does not change with respect to different alternatives, it may not be valid for risk rating as the weights in this case are not preferences but are impacts that may change according to the factors given in Fig. 2. Thus, it is proposed that, for each project option, the impacts and probabilities should be quantified separately by considering the pre-defined factors.

(3) Risk rating without considering corresponding opportunities is meaningless and vice versa. The deviation between the expected and actual performance and (or) utility is usually attributed to risk factors. Risks may decrease the value of opportunities and utility expected from a project. Thus, a measure that reflects the relationship between risks and opportunities should be identified for the assessment of project attractiveness.

Previously, Saaty and Ozdemir (2003) have shown how negative priorities can be defined as relative numbers and used along with positive priorities in AHP. They argue that risks should be treated as negative priorities and may be subtracted from opportunities. They propose alternative measures that may be used to reflect preferences of different decision makers.

Following are the four measures proposed by Saaty and Ozdemir (2003) for risk and opportunity assessment:

1st measure

$$\mathrm{ORR} = \frac{\mathrm{OR}}{\mathrm{RR}}$$

2nd measure

$$\mathrm{ORR} = a(\mathrm{OR}) + b\left(\frac{1}{\mathrm{RR}}\right)$$

3rd measure

$$\mathrm{ORR} = a(\mathrm{OR}) + b(1 - \mathrm{RR})$$

4th measure

$$\mathrm{ORR} = a(\mathrm{OR}) - b(\mathrm{RR})$$

where ORR is the opportunity and risk rating that will be used to rank alternative options, OR is the opportunity rating that reflects the level of conformance of an alternative to a given set of objective criteria, RR is the risk rating that reflects the magnitude of risks associated with an alternative, a is the importance weight assigned by the decision maker to the OR, and b is the importance weight assigned by the decision maker to the RR.

The first measure assumes that for an effective project option risks shall be minimized and opportunities shall be maximized. The second measure also assumes that risks shall be minimized, but the decision maker may select different importance weights, a and b, to reflect his (her) preferences. The third measure is based on the assumption that not all risk is bad, and (1 – RR) value, remaining risk, is considered as a positive value. The fourth measure subtracts risks from opportunities, but different proportions may be used by assigning different a and b values. Thus, the fourth measure may give rise to negative ratings.

It is not possible to propose a single measure that may be used by all decision makers in all kind of problems. The decision maker may choose a measure that best suits his (her) needs and preferences. As an alternative measurement method, the following equation is proposed in this paper:

5th measure

$$\mathrm{ORR} = \mathrm{OR}(1 - \mathrm{RR})$$

The major idea behind this measure is that opportunities must be decreased by an amount, say x, to account for risks present in the project. The value of x is a function of RR. As the risks increase, percentage of deduction should also increase. If it is assumed that there is a direct linear relationship between x and RR, and relationship is simplified to x = RR, then ORR is decreased by an amount (RR)(OR). Thus, assuming that RR leads to a proportional decrease in the OR of a project, the expected opportunities can be expressed by the above given equation.

It should be reminded that, a further adjustment to ORR is required to calculate a more realistic expected opportunities value that takes into account of probability of project being awarded before giving a final bidding decision. However, the objective of this paper is to propose a procedure to calculate attractiveness of potential projects, and modeling competitiveness is out of the scope of this research. Competitiveness depends on bidding strategy of the company, comparative national advantage, competitive strategies of potential competitors, etc. Thus, after the initial project selection stage is over and projects are ranked according to their ORR, decision maker may determine a bidding strategy for the current best option and try to estimate probability of winning the job by considering all factors affecting the competitiveness. If probability of winning is low, in the next step, decision maker may check whether the competitiveness of the company is higher for other projects in the list or not. Consequently, after ORR calculations, an iterative process should be carried out to give a final bid decision, considering the issue of competitiveness.

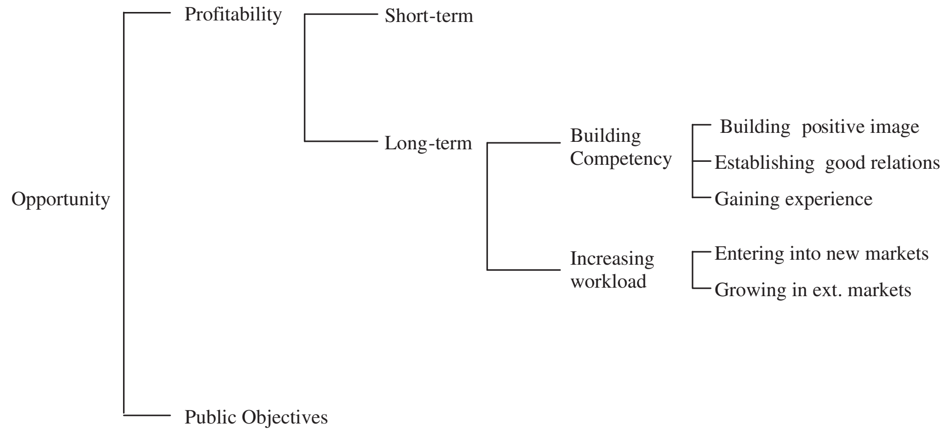
Stepwise procedure of the risk and opportunity assessment methodology

The aim of this proposed procedure is to compare the opportunity and risk of international construction projects by making pairwise comparisons. Following are the basic steps:

(1) By considering the factors, as given in Fig. 2, country, project, and company specific issues that may have an impact on the risk rating of the project are identified.

(2) By using the risk breakdown structure, as given in Fig. 1, for each level of risk hierarchy, comparison matrices are constructed as in AHP and the impact of risk sources are compared by using the 1–9 scale as defined in AHP. While evaluating the impact, the decision maker should answer the question, what is the impact in case where a problem and (or) a variation occurs because of the given risk source? and the decision maker should compare the impact of the risk. The factors identified previously (Fig. 2) should guide the decision maker during this evaluation process. If the evaluation is proved to be consistent, then after the comparison matrices are constructed, consistency values are calculated and impacts are quantified by the eigen value computations. During eigen value computations, first the maximum eigen value of the matrix is calculated, and then the eigen vector corresponding to this eigen value is found. The values in the eigen vector are normalized so that they add up to 1. Thus, each value in the normalized eigen vector is a relative impact value corresponding to each risk source for each project. For more

Fig. 3. An objective hierarchy.



information about AHP and eigen vector computation, readers are referred to Saaty (2000). The overall impact at the lowest level of hierarchy is found by multiplying individual impact values at the upper levels. For example, an overall impact of a problem due to the technical complexity is found by multiplying the individual impacts of risk sources stemming from project, complexity, and technical complexity.

(3) For each risk factor in the risk breakdown structure, the decision maker should construct comparison matrices as in AHP and compare the probability of occurrence of a problem and (or) deviation due to the given risk source by using the 1–9 scale as defined in AHP. While evaluating the probability, the decision maker should answer the question, what is the probability of occurrence of a problem on project success because of the given risk source? and the decision maker should compare the probability of risks for each project. The factors identified previously (Fig. 2) should guide the decision maker during this evaluation process. Also, any strategy used by the company that may affect the probability of occurrence of a risk event should be considered to assess the probabilities. For example, if a foreign company establishes a joint venture with a domestic company and the domestic company deals with the bureaucracy, probability of occurrence of bureaucratic delays may be expected to be lower. If the evaluation is proved to be consistent, then after the comparison matrices are constructed, consistency values are calculated and probabilities are quantified by the eigen value computations. Relative probabilities are the values given in the normalized eigen vector corresponding to the maximum eigen value of the comparison matrix.

(4) Finally, for each project, the impact values should be multiplied with the probability values and added up to find the overall risk rating (RR). However, it should be considered that RR is a relative rating that may change, if the comparison is done by considering different projects. The RR is an indicator of relative risk magnitude of a project when compared with other projects.

(5) To calculate the opportunity rating (OR), the decision maker should identify his (her) expectations from a project, specify the objective criteria, and compare the relative importance of objective criteria by constructing comparison matrices as in AHP. An example of an opportunity hierarchy is depicted in Fig. 3. After calculation of importance weight of the criteria, the decision maker should evaluate the performance of each project according to the given criteria. The performance rating reflects the conformance of the project to the given criterion. Finally, the performance rating and importance weight should be multiplied for each criterion and added up to calculate OR.

(6) The decision maker may use different measures, five of which are proposed above, to calculate ORR. The measure that best reflects the decision-makers preferences about risk and opportunity may be used in this step. The projects can be ranked according to the relative ORR values such that the one with the highest ORR is given the highest priority.

Application of the methodology

The application of the proposed methodology has been demonstrated by using the real data related to two projects evaluated by the business development department of a major construction company of Turkey. The company has been involved in many construction projects abroad and is, especially, experienced in working in developing countries. The sources of competitive advantage in international projects may be attributed to low cost production (mainly due to low workmanship cost) and the ability to manage risks associated with high-risk countries. The names of the contractor and projects are kept anonymous because of confidentiality reasons. The aim of the company is to select a project that satisfies its predetermined objectives to the most. The business development manager, two other staff members working in this division, as well as the authors of this paper have been involved in the application. The authors explained the methodology to the company staff, but they are not involved in the evaluation phase. Thus, the evaluation of risk and opportunity reflects only the opinions of company professionals. A step-by-step procedure followed during the application is described below:

(1) *Review of information about available project options and evaluation of company factors that may affect the magnitude of risk and opportunity:* Some information related to the projects and company is given in Table 1

Table 1. Information about the projects.

	Project A	Project B
Project type	Dam (main works)	Factory (including living complex for personnel)
Country	Pakistan	Qatar
Client	The Pakistan Water and Power Development Authority (WAPDA)	An international private company
Contract and (or) payment type	Re-measurable unit price	Lump-sum price
Expected duration	1187 d	150 d
Size	US$360 000 000	US$35 000 000
Liquidated damages	US$110 000/d	US$30 000/d
Time limitation	Reasonable	Strict
Quality limitation	Reasonable	Very strict
Availability of funds	Yes	Yes

Table 2. Information about the company.

	Project A	Project B
Experience in the country	Very low	None
Experience in similar projects	Experienced in infrastructure projects including dams etc.	Less experienced in industrial projects and housing and (or) building
Familiarity with the joint venture partners	None	None
Major weakness related with the resources	Financial resources	Project management staff
Major strength related with the capabilities	Low-cost rapid construction	Rapid construction

Fig. 4. Impact of complexity on the success of a project.

Project A (impact)

	Technical complexity	Managerial complexity	Contractual complexity
Technical complexity	1	1/2	1/5
Managerial complexity	2	1	1/3
Contractual complexity	5	3	1
		Consistency Index (CI)	0.00185
		Consistency Ratio (CR)	0.00319

Project B (impact)

	Technical complexity	Managerial complexity	Contractual complexity
Technical complexity	1	1/2	2
Managerial complexity	2	1	5
Contractual complexity	1/2	1/5	1
		Consistency Index (CI)	0.00275
		Consistency Ratio (CR)	0.00474

	Impact (Project A)	**Impact (Project B)**
Technical complexity	0.1220	0.2764
Managerial complexity	0.2297	0.5954
Contractual complexity	0.6483	0.1283

Note: CI = $(\lambda - n) / (n-1)$ where λ is the max. eigen value and n is the dimension of the matrix.
CR = CI / RC, where RC is a random consistency for a given matrix of dimension n.
For a 3x3 matrix, RC = 0.58.

and Table 2, respectively. Table 2 summarizes the factors that may affect the impact and probability of risks and includes similar information as in Fig. 2.

(2) *Determination of risk impacts for each project:* Using the risk breakdown structure given in Fig. 1 and based on the information related to the project and company competences given in Table 1 and Table 2, decision makers evaluated the impact of risk factors on the project success (mainly profitability) for each project separately. Comparison matrices have been constructed for each level of hierarchy, resulting in 12 comparison matrices for each project. To demonstrate how impact values for the same risk factors may be different for each project, examples of the comparison matrices are given in Fig. 4. The consistency of all comparisons has been validated by calculating consistency indices and consistency ratios.

(3) *Determination of probability of occurrence of each risk factor in each project:* Using the risk breakdown structure given in Fig. 1 and based on the information related to the

Fig. 5. Comparison of projects with respect to probability of occurrence of problems due to technical, managerial, and contractual complexity.

Technical Complexity

	Project A	Project B
Project A	1	4
Project B	1/4	1

Managerial complexity

	Project A	Project B
Project A	1	1/5
Project B	5	1

Contractual complexity

	Project A	Project B
Project A	1	3
Project B	1/3	1

	Probability (Project A)	**Probability (Project B)**
Technical complexity	0.8000	0.2000
Managerial complexity	0.1667	0.8333
Contractual complexity	0.7500	0.2500

Note: No possible inconsistency in 2x2 matrices.

project and company competences (Tables 1 and 2), decision makers evaluated the probability of risk factors. For each risk factor at the last level of hierarchy, comparison matrices have been constructed where the probabilities in two projects are compared with each other, resulting in 45 comparison matrices. Examples of the comparison matrices are given in Fig. 5. It should be remarked that the probability values are not absolute values; for example, a probability value of 0.75 does not mean that probability of occurrence is 75%, it is just a relative probability rating that has a meaning when it is compared with the probability value associated with another project. For example, when the probability values associated with project A and project B are considered for contractual complexity (as given in Fig. 5), it means that project A will moderately more likely have a problem during the project phase because of contractual complexity as compared with project B. Thus, probability values should be interpreted as relative ratings rather than actual probability of occurrence.

(4) *Calculation of risk rating (RR) for each project:* Table 3 summarizes the probability and impact values for each project. By multiplying the impact and probability values and then summing them up for all risk factors at the last level of risk hierarchy (i.e., 45 risk factors), RR is calculated. Results demonstrate that risk level of project B is higher than risk level of project A. Risk rating values depend on the experiences, strengths, weakness, and risk perceptions of the company making the evaluation. Thus, the level of risk is rather specific to the company and calculated RR values should be interpreted as subjective values. Moreover, one should keep in mind that these ratings are relative ratings and they only reflect the comparative risk levels of the projects.

(5) *Calculation of opportunity rating (OR) of each project:* To calculate the opportunity rating of each project, objectives of the company should be determined. The decision makers found Figure 3 as valid and used it as the objective hierarchy of the company. Relative importance of each criterion and performance rating of each project for each criterion are determined by constructing comparison matrices. The summary of the calculations and the OR of each project are given in Table 4.

(6) *Calculation of opportunity and risk rating (ORR):* Different measures of opportunity and risk rating are introduced to the decision makers, and Table 5 is prepared to facilitate their decision. Decision makers propose that similar weights are given to both opportunity and risk ratings, thus both a and b are assigned a value of 1. All measures indicate that project A is a better choice than project B. It seems to be an obvious decision, as the opportunities provided by project A are greater than project B and project B is much riskier than project A. However, with different projects, the decision may not be so obvious and the decision makers may be forced to select a measure depending on their perceptions about risk and opportunity. For example, the decision may not be so obvious, if OR and RR are both higher or lower for a project when compared with another project (case 1: $OR_A < OR_B$ and $RR_A < RR_B$ or case 2: $OR_A > OR_B$ and $RR_A > RR_B$). In these cases, the choice depends on the selected ORR measure and relative values of OR and RR for a given project. For example, if the 5th measure (ORR = OR (1–RR)) is selected and if OR_A is greater than RR_A, user should choose project A; otherwise, project B should be chosen. However, as the number of project options increase, it is hard to derive rules for selecting the best alternative. Then, decision maker must decide on an ORR measure, choose importance weights, a and b, depending on his (her) risk attitude, and select the alternative that maximizes the selected measure.

Discussion

The proposed methodology is not without limitations. The level of competitiveness of a company determines the probability to win the job and it is one of the major determinants of bid/no-bid decisions. Competitiveness issue is not incorporated into the model. Thus, after risk and opportunity assessment, a further evaluation by the decision makers is necessary to select the right project. Although AHP is a simple technique, some matrix computations are necessary to calculate the eigen vectors, therefore a computer support is necessary. Even though only two projects are compared with each other in the application, the proposed methodology can

Table 3. Risk rating (RR) calculation of project A and project B.

			Project A			Project B		
1st level	2nd level	3rd level	Overall impact	Probability	RR score = impact × probability	Overall impact	Probability	RR score = impact × probability
Project	Complexity	Technical	0.0014	0.8000	0.0011	0.0128	0.2000	0.0026
		Managerial	0.0026	0.1667	0.0004	0.0275	0.8333	0.0229
		Contractual	0.0072	0.7500	0.0054	0.0059	0.2500	0.0015
	Unavailability	Funds	0.0478	0.7500	0.0359	0.0818	0.2500	0.0205
		Labour	0.0165	0.2500	0.0041	0.0207	0.7500	0.0155
		Materials	0.0086	0.1667	0.0014	0.0207	0.8333	0.0172
		Equipment	0.0165	0.8750	0.0145	0.0078	0.1250	0.0010
		Subcontractor	0.0165	0.7500	0.0124	0.0078	0.2500	0.0020
	Vagueness	Design	0.0018	0.1250	0.0002	0.0198	0.8750	0.0174
		Scope	0.0018	0.1667	0.0003	0.0198	0.8333	0.0165
		Contract clauses	0.0053	0.8571	0.0046	0.0198	0.1429	0.0028
		Construction technology and (or) methods	0.0032	0.6667	0.0021	0.0198	0.3333	0.0066
		Risk allocation	0.0053	0.8333	0.0044	0.0198	0.1667	0.0033
		Standards and (or) specifications	0.0018	0.3333	0.0006	0.0198	0.6667	0.0132
		Physical condition (ground)	0.0018	0.8333	0.0015	0.0198	0.1667	0.0033
	Constraints and (or) restrictions	Budget	0.0097	0.8333	0.0080	0.0434	0.1667	0.0072
		Time	0.0039	0.2500	0.0010	0.0434	0.7500	0.0326
		Physical conditions and (or) site	0.0012	0.3333	0.0004	0.0087	0.6667	0.0058
		Climate	0.0006	0.1667	0.0001	0.0434	0.8333	0.0362
	Strict requirements	Quality	0.0044	0.1250	0.0005	0.1015	0.8750	0.0888
		Environmental	0.0044	0.1667	0.0007	0.0262	0.8333	0.0218
		Health and safety	0.0044	0.3333	0.0015	0.0113	0.6667	0.0075
	Poor performance	Consultant	0.0048	0.7500	0.0036	0.3491	0.2500	0.0873
		Designer	0.0030	0.2500	0.0008	0.1843	0.7500	0.1382
		Client	0.0131	0.9000	0.0118	0.1843	0.1000	0.0184
		Subcontractor	0.0131	0.3333	0.0044	0.0980	0.6670	0.0654
		Joint venture partner(s)	0.0131	0.5000	0.0065	0.1843	0.5000	0.0922
	Delay	Site handover	0.0032	0.7500	0.0024	0.0232	0.2500	0.0058
		Design	0.0032	0.7500	0.0024	0.0232	0.2500	0.0058
		Approval and (or) instructions	0.0089	0.8333	0.0074	0.0232	0.1667	0.0039
		Payment	0.0245	0.9000	0.0221	0.0232	0.1000	0.0023
		Dispute resolution	0.0245	0.9000	0.0221	0.0232	0.1000	0.0023
		Material and (or) equipment delivery	0.0089	0.5000	0.0044	0.0232	0.5000	0.0116
	Poor productivity	Labour	0.0067	0.8333	0.0056	0.0077	0.1667	0.0013
		Project management staff	0.0067	0.1250	0.0008	0.0342	0.8750	0.0299
		Equipment	0.0336	0.8333	0.0280	0.0043	0.1667	0.0007

Country	Poor international relations		0.1192	0.5000	0.0596	0.0115	0.5000	0.0057
	Instability of political conditions		0.1192	0.8333	0.0993	0.0115	0.1667	0.0019
	Poor attitude towards foreign companies		0.1192	0.2500	0.0298	0.0115	0.7500	0.0086
	Unfavourable economic environment		0.0424	0.8750	0.0371	0.0552	0.1250	0.0069
	Immaturity of legal system		0.1192	0.6667	0.0795	0.0354	0.3333	0.0118
	Differences	Cultural	0.0057	0.2500	0.0014	0.0024	0.7500	0.0018
		Religious	0.0057	0.5000	0.0028	0.0024	0.5000	0.0012
		Technical specifications and (or) standards	0.0170	0.5000	0.0085	0.0160	0.5000	0.0080
	Societal conflict and (or) public unrest		0.1192	0.8000	0.0954	0.0208	0.2000	0.0042
					RR = 0.6369			RR = 0.8614

Table 4. Opportunity rating (OR) calculations.

					Project A		Project B	
1st level	2nd level	3rd level	4th level	Importance weight (w)	Performance rating (p)	OR = p×w	Performance rating (p)	OR = p×w
Profitability	Short-term	0.6750	0.7500	0.5063	0.2500	0.1688		
	Long-term	Build competency	Build positive image	0.0092	0.6667	0.0061	0.3333	0.0031
			Establish good relations	0.0167	0.2500	0.0042	0.7500	0.0125
			Gain experience	0.0304	0.1667	0.0051	0.8333	0.0253
		Increase workload	Enter into new markets	0.1266	0.1667	0.0211	0.8333	0.1055
			Grow in existing markets	0.0422	0.5000	0.0211	0.5000	0.0211
Public objectives				0.1000	0.7500	0.0750	0.2500	0.0250
						OR = 0.639		OR = 0.361

Table 5. Opportunity and risk rating (ORR) calculated by using different measures.

	OR	RR	O/R	OR + 1/RR	0R + (1–RR)	OR – RR	OR(1–RR)
Project A	0.6388	0.6369	1.0030	2.2089	1.0019	0.0019	0.232
Project B	0.3612	0.8614	0.4193	1.5221	0.4998	–0.5002	0.050

be used to compare any number of projects; however, as the number of projects increase, the size of matrices gets bigger resulting in higher number of calculations.

One of the weaknesses of the methodology is that relative ratings are calculated instead of absolute ratings. The major output of the model is ranking of projects according to their risk and opportunity ratings. However, the relative ratings individually, do not say anything about the absolute and (or) actual risk rating of the projects. Thus, the proposed methodology can be used during project selection while comparing a risk and an opportunity of a certain number of available projects; however, it cannot be used during determination of risk premiums as actual risk and opportunity ratings of projects cannot be quantified with the proposed methodology. Moreover, there is a procedural shortcoming because of the relative rating of options; if a new project option comes into the agenda, computations should be repeated as the relative ratings will change. Also, it is not possible to use the proposed methodology to evaluate attractiveness of a single project. Only option in this case may be comparing the project option with a hypothetical ideal case and calculating a relative ORR.

Finally, it should be noted that findings of the application reflect subjective judgments of the decision makers and the results may change if the same exercise is repeated by different decision makers. The aim of the application is not to find a universally accepted solution to a problem but to demonstrate the applicability of the proposed methodology to a real life problem.

Conclusion

In this paper, a generic risk breakdown structure specific to overseas construction projects is introduced and a risk and an opportunity assessment process is defined for ranking potential project options while giving bid/no-bid decisions. The major scientific contribution of the research is a new methodology that incorporates opportunity into risk assessment process. Application of the proposed risk and opportunity assessment procedure to real projects demonstrates that it has a potential to help the decision makers to give reliable bidding decisions. As it is a structured process, it helps the decision makers to see the whole picture (both opportunities and risks) in a project option. It helps the decision makers to systematize the decision-making process, to express their personal judgments on levels of risk and opportunity explicitly, and to make comparisons among different project options based on quantitative ratings. Usually, the project selection task is carried out by the decision makers based on gut feeling and intuition. This methodology uses the subjective information that would otherwise be lost and creates a relatively objective platform for the comparison of alternatives. If the same methodology is used for all international project options in a construction company, risk and opportunity evaluations are stored in a database, and the actual outcomes of projects are also recorded, it may turn out to be a learning tool for an organization and may improve organizational memory.

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