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A model for project risk assessment and valuation

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ABSTRACT

The review of project risk management processes shows that risk assessment is the first step after risk identification to achieve more information on project risks. As an intermediate step between the risk identification and responding processes, risk assessment helps implement these processes. By implementing this process, more project risks can be identified through better understanding the relationships between the risks and identifying their cause and effect chain. Besides, as a consequence of a better understanding of the risks, the risk assessment process allows better identifying and implementing proper methods for responding to risks. As another achievement of this process, the value calculated for each risk allows prioritization of risks for consuming the limited project resources based on higher priority and effectiveness. Besides, calculating the total project risk value by summing values of individual risks allows determining the actual value obtained from executing the project. This information may specifically help managers to form their project portfolios. To meet goals mentioned above and based on a comprehensive literature review by evaluating existing models, this study identified the key factors and indicators of project risk assessment to propose a model for assessing the project risks.
Keywords: Project risk assessment, Risk relationships, Risk value, Risk prioritization, Risk assessment criteri

Introduction

This study aims to develop a comprehensive model for project assessment and valuation. This study highlights the need for a clear understanding of the dimensions and requirements of this process, especially those that are points of disagreement by most scholars. In this case, the literature in this regard and the models developed by different scholars are reviewed, the criteria introduced for assessing the project risks are presented and analyzed, various kinds of relationships between the project risks are evaluated, and the goals and methods for risk valuation at the individual and the whole project levels are examined. Finally, the research model is presented to resolve existing defects in previous models.

Methodology

This study is an applied study in terms of objective and a descriptive study in terms of methodology. It is classified as a rationalized study in terms of approach and a retrospective one in terms of time. Besides, this study is a conclusive study in terms of performance. In response to the demand identified in this study, the models and standards developed for risk assessment and valuation and their differences were examined and discussed through literature review based on desk study. Finally, a proper model is presented to meet the need for project risk valuation and assessment.

Project risk assessment

Despite the differences of project risk management models, all researchers emphasize implementing a risk assessment process to achieve a better understanding of risks. Accordingly, project managers will focus on high-priority risks and reduce the project uncertainty based on resulting information [3].

Specific criteria should be determined for risk assessment. The most common criteria suggested for risk assessment include [5-6-7]:

1. The probability of occurrence: historical data, probability prediction techniques, and experts' opinions are mainly used individually or simultaneously to calculate the probability of occurrence of a risk. Using historical data, the previously occurred events are identified, and their probability of occurrence in the future is extrapolated. Probability prediction techniques analyze systems and activities as well as failure and success modes. The experts' opinions on estimated risk probability value are collected and extrapolated under a structured process based on all current information such as historical data, system specifications, organizational features, and test results.
2. Impact of occurrence: the impact analysis determines the nature and type of consequences of a particular event. An event may be associated with a wide range of outcomes with different sizes affecting different objectives and stakeholders. To calculate the impact of occurrence of a risk, the interaction between risks and the secondary impacts of risk occurrence on the project should be considered. Cost, time, and quality are criteria usually used to assess the impact of risks.
3. The urgency of handling: risks that need to be handled and respond to shortly are considered more urgent. The urgency indices include the time required to respond to risks and the visibility of signs used to estimate the probable time of risk occurrence.
4. Manageability: the occurrence of some events cannot be assessed and managed. In such a case, two approaches are taken to deal with these type of events. In the first approach, the management reserve is considered to deal with such events, while the project is redefined in the second approach.
5. Controlling factors: the significance level of risk is also dependent on its controllers. Identifying controlling factors and estimating their effectiveness is of particular importance to judge whether efforts must be made to enhance a controller or find a solution to deal with the intended risk.
6. Uncertainty in estimates

The following items can be expressed to criticize the criteria as mentioned earlier:

- Manageability can be used for preliminary screening to identify risks within the project scope, and it cannot be considered an adequate independent criterion for calculating the risk value.
- Controlling factors can be translated into the probability and impact of risks as the probability and impact of a risk decrease or increase with increasing or decreasing the number of controlling factors.
- To consider the uncertainty of estimates, it should be noted that calculating other criteria under optimistic, realistic, and pessimistic conditions allows eliminating this criterion in calculating the risk value.

It is unrealistic to consider the project risks as independent events and ignore the sequence of events, the cause and effect relations among the events, and interactions between risks [10]. Identifying risk interactions not only helps accurate assessment processes but also help to identify more risks [8]. Some studies on the interaction of risks are reviewed below.

Akinci and Fischer (1998) used the knowledge maps to demonstrate the relationships between uncontrollable risk factors (such as economic, political, customer-related, and subcontractor-related criteria) and cost increase variables for ranking the risks of construction projects cost increase [8].

The relationships between the risk causes, risk events, and their results on the project performance were shown by Tah et al. (2000) using the risk breakdown structure (RBS). It was assumed that the dependence of risks could be analyzed even at the risk group level. [9]

Han (2001) defines five groups of risk events, each with a prior probability and a set of relationships with other variables, so that the probability of other risks decreases or increases with the occurrence of an event. (11)

To show the interactions between the project risks, Chauveau (2006) used vectors, each with an (i, p, type) label. This label shows the impact on the probability, the impact on the following risk, and the type of interaction. Three main destructive, constructive, and modifying types were identified for interactions. Upon the occurrence of a risk, one or multiple risks are eliminated in destructive interactions. In constructive interactions, the occurrence of a risk event causes another risk event happen, whereas the occurrence of a risk changes the probability or impact of another risk in modifying interactions [8].

Remington and Pollack (2007) placed the most significant risks on a circle and showed their interactions by vectors. The risks that are the initial point of interaction for several vectors can have a significant impact on the project. Besides, a risk may be affected by the occurrence of multiple risks leading to a significant change in its probability of occurrence [8].

Eybpoosh (2011) plotted vectors between vulnerability area, risk source, risk event, and risk result to help a better understanding of the cause and effect hierarchy between the risks. Despite the strengths of this method in facilitating risk identification and classifying risks, it suffers from being dependent on individual judgments and the number of samples [10].

The model presented in Mehdizadeh (2012) first considers the relationship between the risk events in the form of the RBS. He acknowledged that RBS fails in considering the interactions between the risks because of its hierarchy structure. Hence, vectors with a particular direction and magnitude (indicating its influence) were recommended to be used. The aim is to correct the risk criteria values considering their interactions. A dynamic analysis and assessment process is required, and these values should be repeatedly corrected to achieve realistic risk criteria values.

Based on the studies mentioned above, the relationships between the project risks are considered in these two categories:

- The occurrence of risk will change the probability of the occurrence of another risk. This type of relationship is observed in two modes. In the first case, a risk group is considered a separate risk when the occurrence of a risk group implies the occurrence of all risks in its subgroups. In the second case, the cause of occurrence of risk is considered a separate risk. It should be noted that there may be multiple causes to affect the occurrence of a risk in this mode, and the probability of occurrence of risk varies depending on which one occurs.

- The occurrence of risk is associated with a change in the impact of another risk. In this case, the impact criteria of a particular risk are affected by the occurrence of other risks which are out of the cause and effect chain and defined classification of that risk.

Project risk valuation

Project risk valuation is performed based on the information obtained from assessing risks. This process aims to:

- Calculate the total project risk. Calculating the actual value of a project allows comparing projects to select the best project to participate in the project's portfolio of an organization. It also calculates the total revenue from implementing the project and provides a clear understanding of the project turnover for investors to make financial decisions. It is necessary in this regard to calculate the project risks to compare them more effectively and determine the actual income from the project.

- Determine the significance of risks. Due to limited project resources, the project risks should be ranked to take the necessary measures for handling and responding to risks. In this regard, the project risks are suggested to be divided into the high, intermediate, and low classes based on their importance according to ISO 31010 (2009) and PMBOK (2017). The risks in the high class are prioritized, and aggressive responding strategies are considered for such risks. In contrast, the risks in the low class are negligible, and no measure is required to deal with such risks. These risks are only placed in the watch list, or the contingency reserve is considered for such risks [2, 3, 7].

The project risks can be compared comprehensively when all risk values are provided on the same scale. According to Santos et al. (2008) and Mulcahy (2010), the expected monetary value (EMV) calculated by multiplying the probability of a risk by the financial damage caused by the occurrence of the risk (the sum of all impacts after converting to the cost index) is used for this purpose. To convert the impact values (quality and time) to cost index, using multicriteria decision-making (MCDM) tools is suggested. In comparison with simple methods, MCDM methods can calculate the actual weight of indices, use more indices, and perform a sensitivity analysis on the values of indices. MCDM methods are divided into two general groups of compensatory and non-compensatory models. Note that the non-compensatory models cannot be used for ranking project risks because no exchange should exist between indices while the impact values of risks (cost, time and quality) affect each other.

Numerous models have been developed for project risk assessment and valuation; some of them are introduced below:

Baccarini et al. (2001) proposed a model for calculating the value and ranking of project risk. This method is based on determining the status of risk drivers. Risk drivers are apparent phenomena affecting the status of project risk. Some drivers introduced in this model are project complexity, project location, execution speed, project organization experience, technological requirements, the intensity of activities, and customer features. After determining the risk drivers status, the risk value of each driver is calculated on a semi-quantitative scale for each project objectives (including time, cost, and quality) in the form of increased project costs, delayed project delivery, and project efficiency for customers. Project total risk score is determined in each project objective by summing all driver risk values. [12]

This model considerably facilitates and also makes project risk valuation full of errors with a very general overview by translating all risks into a few risk drivers. Moreover, this model is applicable for a primary screening of proposed projects and cannot determine total project risk value.

Cooper et al. (2005) introduced a set of indices to calculate the probability and the impact of risk occurrence in project components. For example, to calculate the probability of risk occurrence in a component, the type of contract is introduced as an index assessing the probability of risk occurrence respectively high and low for a complex and standard contract. As another example, to calculate the impact of risk occurrence in a component, customer satisfaction is introduced as an index assessing the impact of risk occurrence high or low based on conflicts with customers or customer satisfaction with that project component. The probability and impact values are expressed on a semi-quantitative scale. So the risk value for each component is calculated from the formula $P+C-P*C$ (where P and C represent the mean indices value for probability and impact, respectively). [5]

This model introduces a limited number of components and indices for calculating the risk probability and impact values. Moreover, it is incorrect to calculate the mean values of different indices with different natures and relative significance to calculate the probability and impact values. Only MCDM techniques and methods for converting all of them to a criterion can be used. Besides, summing the probability and impact values gives no concept for calculating the risk value as they are completely different without any common feature.

An FMEA-based model was proposed for risk assessment by Santos et al. (2008). In this model, the risks in each risk category are identified, and the probability of occurrence, impact intensity, and identification potential are determined for each risk. The risk score is calculated by multiplying these three values. A higher score means the higher significance of the intended risk. [1]

Despite the easy application of this model, it does not cover all requirements for project risk assessment. The relationships of risks, risk groups, and assessment criteria have not been considered. Furthermore, ignoring diverse impact criteria and providing only a number instead of time delays, increased budget, and reduced quality reduce the accuracy of calculations.

Mulcahy (2010) uses a different method to calculate the project risk score. At first, the score for each risk (the product of the probability and impact values on a semi-quantitative scale) is calculated. Then, the most critical risks are identified and other risks are excluded. Finally, the average score of remained risks is calculated as the project risk score. [4]

This method gives no criterion for excluding low-significant risks and selecting the most significant risks. Moreover, averaging the values of project risks gives no reliable results for comparing a small project with a small number of risks and a big project with a large number of risks.

Mehdizadeh (2012) proposed a model for risk assessment which the risks are classified based on the RBS. The probability of risk occurrence and its impact (based on three criteria of project cost, time, and performance) are calculated. The product of the probability and impact values is used as the risk value. In the next step, for easier comparison of the significance of risks, the risk value calculated for these three criteria on a continuous quantitative scale is converted to a value in the range of 1 to 5 based on the range determined for each impact criterion. To calculate the risk group value, the risks value in the subsets are added separately for each impact criterion. Continuing the same process to the upper levels, the total risk value of the project is calculated for each impact criterion. [8]

Given that risk management is dependent on individual key actors in the supply chain, each with different terms and techniques to deal with risks, a common language is required for explaining risks and facilitating consistent risk assessment. This common language can be achieved by using the RBS (as discussed in this model) [9]. However, developing such an RBS is complicated and somewhat ambiguous, as risks can be categorized by different methods, and there is no apparent logic for generating the RBS. Besides, there is no consideration for the urgency of risks responding in comparing risks relative importance.

Han (2001) considered the causal relations between the variables which affect the project success. Each variable has an initial probability value and a set of relations with other variables. Vectors with specific direction and effect value are used to explain the interactions between the variables. The probability of occurrence of events is predicted based on these relations through analytical processes. The project variables are first defined, and the initial probability of each variable is determined. The relations are then developed for each pair of variables. The effect of relations is determined by Monte Carlo modeling to calculate the probability of occurrence of each event in the future. The variables in this method are classified into five groups of local variables (economic, social, environmental, climatic, and geographical conditions of the project), contractor strategies (contractor source, experience, managerial capability, and relations of the owner and strategic partners), intermediate variables (to disseminate initial conditions in the model results), project results (project cost uncertainty, project scheduling uncertainty, contractor capability in project execution, the potential for future work reception, developing the market share, and developing customer relationships), and output variables (including project profitability and other benefits). [11]

This model has been developed in such a way that it can be employed for assessing the project risks to make decisions on selecting or rejecting a project. It has limited applications for project risk management. It is also unrealistic to consider local conditions and contractor features as main factors causing project risks. Other factors such as project features and organizational strategies also affect the project risks.

Conclusion

Based on the literature on the project risk assessment and the summary of views on assessment criteria, risk interactions, valuation goals, and the models developed for this purpose, the following guidelines are presented to develop a model for project risk assessment and valuation.

The three criteria of the probability of occurrence, impact of occurrence, and urgency of responding are considered to select the risk assessment criteria.

- The probability of occurrence is calculated in a percentage range from 0 (impossible) to 1 (definitive).
- The impact is assessed generally for all projects in proportion to negative and positive risks in increased/decreased costs, time delays/acceleration, and decreased/increased quality. More impact areas can be considered in specific projects following features of different industries so that safety threat/provision and environmental destruction/protection are of great importance in construction projects. Notably, all values for the impact of risk occurrence can be converted to a cost scale using contract contents, legal requirements, experts' opinions, and other information resources by MCDM techniques.
- The urgency of the responding criterion is calculated by dividing the time elapsed from the start of the project by the interval between the probable occurrence time of the intended risk and the start of the project. This is a value in the range of 0 (the possibility of occurrence at a very distant interval of time) to 1 (the possibility of occurrence at a very close interval of time). Values larger than 1 imply passing the probable occurrence time and eliminating that risk from the list of project risks.

It is necessary to consider the interactions between the risks to calculate the probability and impact values. The following two methods are suggested in this model based on the goal of risk valuation.

1. Calculating the project risk value

The real value of each risk is calculated by multiplying the probability and impact values. The project risk value is calculated by summing all risk values. Those risks directly affecting the project should be considered in this calculation, not the risk factors and risk groups.

2. Prioritization of risks in a project

The probability values of 1 (low probability) and 10 (high probability) and impact values of 1 (low impact) and 10 (high impact) are calculated for each risk on a semi-quantitative scale. The probability, impact, and urgency values are multiplied, and the product (ranging from 0 to 100) is used for calculating the relative value of each risk and prioritizing the project risks. A greater value means the higher priority and significance of the intended risks for being addressed.

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