Project Portfolio Selection Based on Risk Index

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Abstract: Organizations, especially project-based ones, always face a set of project proposals to select from to meet their revenue targets. They maximize their profit from projects by evaluating the proposals and selecting the best for their portfolios. For this purpose, there are various criteria for considering different aspects of organizational goals. A criterion, which most models have failed to consider, is the project risk as well as the effect of project selection on the project portfolio risk. This becomes more important when it is realized that a major goal of creating organizational project portfolios is to mitigate the risks posed to organizations by the failure of single projects. This study proposes a project portfolio selection model based on the risk evaluation of project proposals by identifying the requirements of necessary processes for this purpose through a literature review and analysis of the developed models.

Keywords: project selection, project portfolio risk evaluation, project value, interactions of risks

1. Introduction

Defined as a series of plans, projects, or operations managed collectively to reach strategic goals, a portfolio is created to coordinate and align organizational projects, achieve monetization through diversification, and mitigate systematic risk (1),(6). Trying to "do what is right", portfolio management seeks to establish strategies, create values, and manage resources (6). For this purpose, portfolio management includes diverse processes which are classified by the PMI's standard for portfolio management (2017) as three categories of "Defining", "Aligning", and "Authorizing and Controlling", which the portfolio components are classified, evaluated, selected, and managed in the aligning process group. In Pajares & López (2014) research, portfolio management processes were divided into "alignment" and "operational" processes group, the first of which includes project valuation, ranking, and selection as well as project portfolio balancing and portfolio risk analysis (4). This study aims to develop a model to select and add projects to portfolios based on project risk evaluation through alignment processes.

It is essential to address the foundations and models regarding project portfolio development and risk evaluation to provide the necessary information for developing a portfolio development model based on risk evaluation. Therefore, these two concepts are discussed in two sections, and different previous models are reviewed and analyzed.

Research Methodology

This retrospective applied-descriptive study adopted a rationalistic conclusion-oriented approach. The desk method was employed to review the previous studies and proposed models and analyze their strengths and weaknesses in this study to develop a novel model that is free of previous flaws.

Portfolio Development

Facing various constraints on capital, resources, and knowledge, organizations always have to select from numerous projects. It is important to select projects correctly, for organizations can boost the resultant values of projects up to 20-40% through the right selection without increasing the current costs (8). Nevertheless, organizations are inefficient in selecting the right projects in many cases, something which is caused by prejudgments, flawed judgments, lack of correct criteria for project evaluation, inability to identify dependencies of criteria, inability to create a simple but efficient format for portfolio development, and inability to intervene risks properly (8) (9). Showing what matters to organizations, evaluation criteria should support the project portfolio management goal that is to maximize the values obtained from portfolios. The value of a project estimates the extent to which the project supports an organization in achieving the desired goals; therefore, organizational features must also be considered in addition to portfolio features.

The conventional portfolio development method only considers project profitability and selects projects regardless of strategic decisions. However, financial criteria, which are difficult to calculate, present only an incomplete introduction of what is important for a business (8) (10). According to Ullman & Levine (2009), it would be wrong to use financial criteria as the only project valuation criteria due to uncertainties about data accuracy, mere application and proportion for long-term projects, inaccuracy of equal risk distribution assumption during the project lifetime, and loss of a large amount of data to convert them into financial units. (7)

According to the research literature, the following points should be considered in determining project evaluation criteria for portfolio development (5),(8),(6):

- Using diverse criteria such as market conditions, contractual conditions, technical problems, previous experiences, compliance with rules, social effects, capacities of organizational resources, current risk status, value creation for stakeholders, and support for organizational strategies.
- Considering the importance of employing an optimal number of criteria for showing the project value. For this purpose, the important criteria that are difficult to calculate should not be disregarded (*e.g.* effects on learning and organizational capacities); besides, several criteria should not be used for the cases that are easy to highlight (*e.g.* financial criteria).
- Clarity of portfolio development criteria. For instance, "customer satisfaction" is an unclear criterion; however, "customer complaint reduction percentage" and "company ranking in customer satisfaction" are clear criteria.
- The Proportion of criteria to organizational conditions. Different organizations execute various types of projects, and there are no equal criteria that can be used for all projects. Furthermore, each of them creates their defined values in different ways.
- In addition to determining criteria and calculating their values, the value of a project is measured concerning other projects. Therefore, the order of adding projects to the portfolio can even affect the project value due to achieving synergy for projects, gaining experience, and repeating similar projects.
- Uncertain values of criteria. It is recommended to use certain methods such as the three-point estimation or Monte Carlo modeling to consider the effects of the existing uncertainties; however, these methods require massive calculations, and it is very time-consuming to prepare the input data.

According to an analysis of existing portfolio development models, a series of following requirements would be recommended to be fulfilled in project portfolio selection processes: considering internal and external strategic problems, making processes flexible and matching them with a variety of existing techniques, making processes simple and logical, granting users easy access to data, using specific and common criteria to compare projects, evaluating projects regularly to revise decisions, performing screening processes to delete flawed projects, considering interactions and dependencies of projects, revising processes and obtaining feedback of changes, considering organizational constraints on resource supply, and matching processes with decision-making environments (9).

Many methods have been developed to select the right project for portfolio development. Some of such methods are reviewed below.

The PMI standard for portfolio management (2017) addresses portfolio development topics under the processes of "define portfolio" and "optimize portfolio". The key processes of "define portfolio" include identifying the eligible components meeting portfolio conditions, classifying portfolio components based on decision-making criteria, and evaluating portfolio components through ranking models. However, the key processes of "optimize portfolio" include rescoring for ranking portfolio components, conducting a risk analysis of portfolio components based on organizational models, determining abilities and capacities of existing resources, selecting components of higher priorities, and identifying portfolio components that must be suspended and ranked again. (6)

Vergara (1977) proposed four steps to achieving the best series of projects in construction project portfolios. In the first step, the existing projects are evaluated separately, whereas project sets are evaluated collectively in the second step to determine the features of the existing portfolio. The third step selects the new potential projects for which the company can participate in their auctions. Finally, the fourth step selects the best portfolio of the organization by adding the novel projects one by one and determining the optimal auction price for the new project (10).

Financial criteria and their uncertain values were employed to propose a project selection model in Han et al (2004). The values of financial criteria such as return on capital and current portfolio risk are first calculated. The project proposals are then financially evaluated to determine their resultant cash flows. Based on the output values and minimum level accepted by the organization, some projects are then excluded. The designated projects are then separately added to the new proposed portfolios, which are then evaluated and scored. The resultant scores are then used to select an appropriate portfolio, and organizational-strategical considerations are then employed to select the next projects and modify the current portfolio through feedback. (10)

A five-step model was proposed by Archer & Ghasemzadeh (1999) for project selection and portfolio development. The "pre-analysis" step ensures the proportion of the project to different portfolio strategies. In the "single project evaluation" step, the values of some parameters such as the net project value and project risks are determined by using the information obtained from the project feasibility analysis or the results of previously finalized projects. Based on the values calculated in the previous step, the "screening" step excludes the projects which fail to meet the predetermined criteria to reduce the number of projects which should be analyzed simultaneously. The "optimal portfolio selection" step considers the interactions of projects including dependencies, competition for resources, and scheduling along with the value determined for every project based on the parameters calculated in previous steps. Multi-criteria decision-making methods, scoring models, and portfolio matrices are then employed to select projects and create the new portfolio. Finally, a comprehensive view of features of the included projects (*e.g.* risk, net project value, and completion time) is provided in the "portfolio adjustment" step to analyze the effects on resources or projects, in addition to, adjust portfolios to achieve organizational goals optimally. (9)

It was recommended by Purnus, & Bodea (2014) to determine the valuation criteria and scoring scale of each criterion to develop a quantitative model, which can evaluate and prioritize projects. The scoring method of each criterion and the score of each project were then calculated to finally prioritize the projects through a single-criterion or multi-criteria approach. (5)

A mode was proposed in Han (2001) based on project profitability. First, this model performs a screening process based on the project position in the predefined profitability range. Based on the multiple criteria which include other interests obtained from the project execution, a comparison is drawn between the value of each project and the minimum value accepted by the organization by converting the criteria into a single value for projects. Accordingly, a project is then included or excluded in the project portfolio of an organization. (12)

From a critical standpoint, it can be stated that some of these models have disregarded the interactions between a project proposal and the existing projects as well as their mutual effects to include a project in or exclude it from the portfolio. These models have only considered projects separately. According to Hernández et al (2011), a project with the highest NPV (net project value) is not necessarily the best project to add to a project portfolio (11). Instead, the interactions of projects can greatly affect the portfolio value. At the same time, these models try to compare projects based on vague and limited criteria such as financial factors. This limits the use of these models and makes them inefficient in creating an optimal portfolio.

Portfolio Risk Evaluation

Beyond the project risk evaluation, the portfolio risk evaluation is important in terms of structural risks in addition to the risks of portfolio components, differences of portfolio goals, and relationships between risks of different projects and their mutual effectiveness.

Since the area of the portfolio is much less considered than the area of the project, only a few models have been developed for portfolio risk evaluation. Some of them are reviewed below.

The PMI standard for program management (2017) proposes a series of actions for project risk evaluation in multi-project environments. These actions include evaluating the quality of risk data to determine risk and non-interference of people's preferences in data collection, evaluating probability and risk impact to determine the importance of risks and prevent energy loss for the sake of equal attention to all risks, grouping the risks to classify opportunities and threats in the form of a risk breakdown structure (RBS), determining risk urgency to prioritize risks based on the need to quickly and urgently respond to risks, and evaluating relations of risks to determine how risks affect each other. Finally, all pieces of information are employed to show projects' threats and opportunities. (2)

To criticize the proposed instructions, it can be stated that although this standard generally proposed the necessary actions for risk evaluation, it failed to address how to calculate the risk value in projects or how to prioritize projects. However, this standard is considered the mutual relations of risks. In addition, not only does consider the mutual relations of risks help make the risk evaluation process accurate, but it is also possible to identify more risks in this way (3).

The concept of "value at risk" (VaR) was proposed by Han et al (2004) to calculate the portfolio risk. VaR indicates the expected financial loss during a specific time at a specific reliability level in a project. Moreover, VaR is obtained by considering investment interval, deviation from normal (to express a specific reliability level), standard deviation (to express fluctuations of financial factors), and the initial project capital. (10)

It can critically be stated that this model proposes no method for calculating the standard deviation, which results from the risk evaluation of portfolio projects, and merely expresses how to use it to compare projects. Therefore, this model constitutes a small component in portfolio risk evaluation tools and needs to employ many other tools as preliminary and supplementary techniques. In addition, comparisons are only based on the financial factor; hence, it is necessary to use numerous processes to calculate other criteria and translate them into financial criteria.

A model was proposed by Ravanshadnia et al (2010) to calculate the risk of construction projects portfolio. In this model, risks are first divided into five major categories, *i.e.* risks of construction and exploitation, procurement and equipment, design, contract, and studies. The probability and outcome of each risk as well as its value in a fuzzy environment are then determined. The values of major risks are then calculated by adding the fuzzy numbers of risk values. The project risk is then determined by converting the fuzzy numbers of risk values into real numbers and calculating the weighted mean of major risk values. Finally, the portfolio risk magnitude is determined by adding the products of each project weight multiplied by each project's risk value. Project weight is calculated by dividing the expected income of each project by the total incomes of all projects. (1)

It can critically be stated that this model disregards the correlations of projects and interactions of risks. This model also fails to identify many risks due to limiting the existing project risks to five categories; as a result, it decreases the accuracy of calculations. In addition, only the financial input is considered in this model to calculate the weight of a project; however, a project is not executed in the portfolio merely to achieve revenue targets, which cannot be the only criterion for determining the importance and priority of a project.

Conclusion

According to the analyses of portfolio risk evaluation and the criticism of existing models, a novel project selection model is proposed to create portfolios based on project risk evaluation. The proposed model consists of two steps, *i.e.* initial evaluation and accurate measurement. During all steps of this model, every project is added separately to the existing portfolio. The values and relations are then analyzed.

1- Initial Evaluation

A screening process is performed in the first step along with a general evaluation to identify and exclude all the projects that are inappropriate for the portfolio based on their risks. As a result, a smaller number of projects enter the next step for more accurate evaluation. For this purpose, a series of criteria that indicate the current risk status of a project should be employed for project valuation. The features of projects, organizations, industries, and project implementation environments are taken into account to determine these criteria.

After the status of every criterion is determined between 1 (appropriate status) and 5 (inappropriate status), the relative importance of the project risk should be set by a semi-quantitative scale ranging from 1 (low importance) to 5 (high importance) for the initial evaluation of the project risk. The resultant importance value is then multiplied by the criterion status value to determine the criteria value. This process should be performed for all project proposals with the same series of criteria. finally, the criteria values are added to calculate a single number for the project risk score. It is then possible to provide initial rankings of projects based on their risks by comparing the projects' risk score. In other words, the lower the resultant project risk score, the better the project status for placement in the portfolio. Table 1 shows a set of proposed criteria.

Table 1. Initial evaluation of project risks

Criteria for Initial Evaluation of Project Risks	**Status (1-5)**	**Importance (1-5)**	**Value**
Clarity of project goals			
The novelty of project in the organization			
Complexity of deliveries			
Client's financial capacity and payment ability			
Each of access to the project site			
Presence of hazardous materials in the project			

The simplicity of obtaining necessary approvals			
Social sensitivity to the project execution			
Availability of equipment			
Dependency of processes			
Clarity of contracts			
Use of resources shared with other projects			
Revenue of the project			
Necessary execution and management capacities			
Consistency with mission declaration			
The total value of criteria as the relative score of project risk			

Accurate Evaluation

With a limited number of projects in the second step, a more extensive and accurate evaluation is performed to determine the real value obtained from the project execution by considering the existing risk value. The accurate evaluation of projects includes the following steps:

- Calculating the occurrence probability of every risk in the project: The occurrence probability is measured in percentage and expressed as 0 (impossible) to 1 (imminent).
- Calculating the impact of risk occurrence on project goals: Based on the risks are positive or negative, the impact criterion is measured in the form of the cost increase/decrease, time delay/acceleration, and quality decline/improvement for all projects in general. More areas of impact can also be considered concerning specific projects and features of different industries. For instance, safety threat/insurance and environment destruction/protection are important impact criteria to consider in construction projects. It is also possible to convert all of the above values in terms of cost (dollar, euro, *etc*.) by using the contract contents, legal requirements, expert opinions, and other information sources in addition to using multi-criteria decision-making methods. In contracts, a sum is often defined as a penalty or reward for delay or acceleration in project completion time per day in comparison with the allotted time. Some other penalties are also considered for any flaw or inefficiency of project products.
- Calculating the value of every single risk: The value of every risk is calculated by multiplying its probability by its impact.
- Calculating project value at risk: It is determined by aggregating the values of all project risks. For this purpose, it is necessary to consider the risks which have direct effects on the project and to avoid using the risk factors and the risk categories in our calculations.

It is important to consider the relations of risks in a project and between projects in a portfolio to determine the correct values of probabilities and effects of risks. A project faces different conditions in achieving its goals when it is affected by other projects. Consequently, the project portfolio is affected by the inclusion or exclusion of the projects. Risks interactions between projects must be considered in this case. In this model, the relations of risks, which can directly affect the project goals, are defined as below:

1) The occurrence of risk leads to a change in the occurrence probability of another risk.

This kind of relationship can be observed in two cases. First, when the group of risks is regarded as a separate risk, the occurrence of a risk group means the occurrence of all subgroup risks. Second, when the occurrence factor of risk is regarded as a separate risk, it should be noted that a risk can have many occurrence factors, and depending on the emergence of each occurrence factor, the occurrence probability value of that risk can change.

2) The occurrence of a risk results in a change in the occurrence impact value of another risk.

In this kind of relationship, the occurrence of a risk, which can be placed outside the cause-and-effect chain or the classification set for another specific risk, changes its impact value. If a system suffers from the occurrence of some events, it will be more vulnerable to the outcomes of other events.

3) A specific risk repeats in the project portfolio components.

This is important in two aspects. First, considering these risks at a macro level would help plan for an effective response to those risks. For instance, all projects of a portfolio can face the risk of increased material price. In this case, the organization can justify the procurement of a large warehouse for material storage to take a fundamental step in mitigating this risk impact. Second, if a risk that is analyzed unimportant at the project level is repeated in the portfolio components, it can have significant accumulative effects on the portfolio. Therefore, considering this common problem prevents the exclusion of these risks from the separate risk evaluation of every portfolio component.

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