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Isorisk Curves as a Tool for Increasing Flexibility of Risk Management in Engineering Projects

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Abstract

Engineering projects are characterized by high significance of the risk management. One of the most important tasks of the project risk management is risk prioritization. Prioritization implies that the probability and impact of risks on a project are estimated. The risk probability can be calculated with the help of different methods of random variable estimation. The article shows that though the probabilistic, scenario, expert and statistical methods can be used in practice of project risk management, in the projects characterized by the high uncertainty, such as engineering projects, the robust methods proved to be more productive and reliable.

One of the widely used practical tools of risk prioritization is risk matrix which sometimes called also as probability and impact matrix. The risk matrix includes two dimensions – probability of risks and impact of risks on a project. The article suggests that instead of the risk matrix in engineering projects the more flexible approach can be applied. This approach is based on the application of the risk maps and isorisk curves. The isorisk curves and risk maps seem to be especially useful for engineering projects with big number of various risks and very dynamic environments.

Keywords: Risk management, risk prioritizing, risk matrix, risk map, engineering, engineering projects, engineering management, project risks, isorisk curve, random variable estimation, robust risk estimation

1 Introduction

Many projects and programs are characterized by the high importance of risk management. Typically risk management issues are addressed with the help of the traditional project management tools and techniques [1–4]. Within the area of project risk management one of the crucial tasks is risk prioritization [5, 6]. Risk prioritization is the task that should be solved within different phases of the project life cycle (project analysis, project planning and project execution) and should allow a stage-by-stage implementation [7]. Therefore, effective project risk prioritization tools must help not only to identify risks and their priorities, but also to monitor and track the changes of risk characteristics throughout the whole project life cycle.

The issue of project risk prioritization is especially important for engineering projects. Even in simple engineering projects the number of the identified risks can easily amount to as many as several hundreds [5]. Obviously, all the identified risks have different potential impact on the project and should be treated differently. One group of risks can be considered as rather immaterial and therefore ignored. Some other risks may become the most important issues for the whole process of project management, despite of their initial seeming unimportance. The process of risk prioritization allows distinguishing various risk categories in terms of their significance for the project and the most appropriate managerial approaches to deal with them.

In order to prioritize project risks their potential impact on project and probability of their occurrence are to be estimated and on the basis of these estimation risks can be put into different categories [2, 3, 5]. Though there are traditional methods of risk probability estimation and practical tools for visual categorization of risk these methods and tools have some limitations in the context of engineering project risk management [8–10].

2 Traditional and robust methods of project risk probability estimation

As it was said in Introduction, in order to perform the task of project risk prioritization the probability of the risk and the potential impact of the risk on the project should be evaluated. The first task is relatively easier and can be performed by the specially trained analyst with the help of the statistical data and models of potential damage appraisal. However, the probability assessment needs more complicated specialized methods to be applied [11].

The most widespread method of the risk probability assessment is based on the model of normal or Gaussian distribution [12]. The popularity of this method is connected with the fact that it is based on the central limit theorem which makes the method easily applicable in different practical contexts. Many random variables in practice are influenced by the big number of various factors, each of which has an insignificant influence. If the impact of these factors on a variable has a linear nature (in other words the total impact of the factors is summarized), the resulting random variable has the normal distribution.

In the practice of project management, especially in engineering projects, risk managers use the models based on beta-distribution [5]. In the reliability theory to describe the operating period of different appliances engineers use models based on exponential, Poisson, Erlang and other distributions. In feasibility studies of capital projects the logarithmic normal and gamma distributions are sometimes used. Uniform distribution is used in different software applications to create the random generators and can be applied in simulation models. All types of distribution can be used in quantitative and qualitative risk analysis [11, 12].

Scenario methods are based on the development of different scenarios that describe the potential project realization in different (for example, the basic and the worst possible) alternatives [3]. Each scenario reflects the political, economic and legal context of the project, the possible project cash flows, the indices of effectiveness and efficiency, potential project results for key stakeholders of the project.

Statistical methods are based on processing quantitative data from the previous observations of risk events for the purposes of calculating main statistical parameters – mean value, dispersion, standard deviation etc., [1, 11]. Statistical methods need the prior collection of data on analogous projects and/or execution of the relevant experiments. If the information about the executed projects and experiments is available, there is the possibility to estimate the distribution functions of the random variables, regression and correlation functions. The most popular method of evaluation in mathematical statistics is the method of maximum-likelihood estimation (MLE).

Expert methods are used to assess unique risk events in projects or other project risks when the quantitative data is insufficient [11]. The experts give their estimations which are processed with the methods from mathematical statistics. The experts should work with the specially developed questionnaires where they need to provide their estimations of risk events probability. The results can be processed with the help of traditional statistical or robust methods. The expert estimations frequently lead to the problem of the averaging the opinions of experts. To avoid this problem the method of weighed estimations can be used which implies that every expert should have a particular weight that reflects the competence of this expert [5].

The traditional methods of the risk probability estimation in mathematical statistics are based on the precise knowledge of the models of the random variable distribution. The main approach is the maximum-likelihood estimation which defines the best estimations for each probability distribution. However, this approach has one significant drawback, namely that the resulting estimations are not resistant to the possible variations from the assumed distribution model. The distributions observed in the real life only slightly correspond to the theoretical models. Hence, the models based on the traditional methods in these conditions frequently lose their usefulness.

Robust methods are based on the estimations that may not be optimal, but they are resistant to the possible variations from the assumed distribution models. These estimations are called robust estimations. The procedures of robust estimations are rather laborious but can be executed with the help of some software applications, including Microsoft Excel.

Titarenko B. analyzed the application of all risk probability estimation methods in the real practice of project management and concluded that in the engineering projects characterized by the high uncertainty the robust methods proved to be more productive [9]. In the article by B. Titarenko, S. Titov and R. Titarenko it was indicated that the robust methods of risk probability estimation imply the change in the practical tools of project risk prioritization [8]. G. Bubnov, B. Titarenko, S. Titov, R. Titarenko demonstrated that the more appropriate for robust methods tools of project prioritization can be risk maps and isorisk curves [10]. Risk maps and isorisk curves are more flexible and allow depicting project risks in more detail than traditional practical tools of project risk prioritization such as a risk matrix.

3 Risk matrix and its limitations

One of the widely used practical tools of risk prioritization is risk matrix (sometimes called also as probability and impact matrix or chart) [4]. This matrix includes two dimensions – probability of risks and impact of risks on a project. According to the assessments each risk is plotted on this two-dimensional matrix. Risks with insignificant probability and impact can be considered as unimportant. Risks with high probability and impact will be of high priority.

Despite the popularity of the risk matrix it has some limitations. First, the risk matrix implies that project managers have to define the risk categories (significant, moderate, unimportant and so on) before assessing and plotting the risks onto the matrix. Second, the risk matrix does not provide opportunities to map the risks and compare their probability and impact, especially if the project manager has to deal with dozens of different risks. And third, the risk matrix offers only discrete diapasons for different types of project risks. In some situations, especially when it is difficult to define in advance the possible risks categories (cells of the risk matrix) and the number of risks in each category, the risk matrix becomes not very flexible for practical use [8].

In such situations the more flexible approach can be applied with the help of the isorisk curves and risk maps that are described below.

4 Isorisk curves and risk maps

In order to draw isorisk curves we need to depict a risk map for a particular project. The risk map is the space with two dimensions – probability and impact of risks. But in contrast to the risk matrix there are no cells that are established in advance. The impact of risks is usually depicted as a horizontal axis. The impact of risks can be measured in terms of the negative (or positive) consequences for the project if the risk event occurs. For example, these consequences can be associated with the potential additional expenses, or time delays, or deterioration of the quality. But only one measure should be selected in advance and applied to all of the project risks. Usually, the impact of the risks is measured in terms of the additional expenses occurring in the case of the risk happens. The vertical axis is used to measure the probability of risk occurrence. The standard approach here is to measure the risk probability along the scale from 0 (the risk is impossibly to happen) to 1 (the risk will definitely occur).

Each risk is plotted as a dot on this two-dimensional space according to its probability and impact estimations. In situations when it is very difficult to estimate the probability and impact of the risk with only two exact numbers the diapasons can be used. In this case the risk will be depicted not as a dot, but as a rectangle. After all project risks are plotted on the map the risk categories can be defined and put on the map. The risk category definition should be based on the analysis of the number of the project risks in each areas of the map, the necessity to establish more detailed category system (project manager can easily introduce two, three or even more different categories), the scope and boundaries of each category. The risk categories can be put on the map with the help of the isorisk curves. The isorisk curve is a curve that consists of the dots with the same product of probability and impact. These curves comprise the potential risks with the same expected consequences for the project and can be used as the boundaries of different risk categories. Let us illustrate the application of the isorisk curves and risk maps for a typical engineering project.

In Table 1 the main estimations of the ten different project risks are given. These estimations include the probability of risk occurrence, the probability of the risks influence on the project, the overall probability of risks (the product of the probability of the risk occurrence and the risk influence), and risk impact on the project (defined in terms of the additional labor time needed to deal with the risk consequences).

Table 1: Data for the risk map for a typical engineering project

Risk event	Probability of risk occurrence	Probability of risk influence	Overall probability of risk (2x3)	Impact of risk on project (additional man-days)
1	2	3	4	5
R1	0,7	0,9	0,63	25
R2	0,7	0,7	0,49	15
R4	0,7	0,9	0,63	5

Table 1: (Continued): Data for the risk map for a typical engineering project

R5	0,5	0,9	0,45	22
R7	0,3	0,7	0,21	13
R9	0,3	0,5	0,15	4
R10	0,1	0,5	0,05	25
R13	0,9	0,9	0,81	17
R16	0,9	1	0,9	22
R18	0,3	0,9	0,63	5

All risks are plotted on the risk map. The overall probability of risks is used to define position of a risk along the vertical axis and the impact of the risk on the project to define horizontal coordinates of the risks.

Assume that after the consideration of the data shown in Table 1 and the risk map the project manager decided to use only two risk categories – significant and insignificant risks. The risks with the expected additional labor time above 5 man-days should be considered as significant and the manager should elaborate the contingency plan to deal with these risks. The risks with the expected impact below 5 man-days can be considered as insignificant and due to this fact the project manager can ignore them and concentrate his efforts only on the significant risks. The isorisk curve in this case goes through all the dots which coordinates on the risk map have the product equal 5. The coordinated of these dots are (5; 1), (10; 0,5), (20; 0,25) and so on. The resulting risk map with the isorisk curve separating significant risks from insignificant is shown on Fig.1.

From Fig.1 it is clear that such risks as R4, R7, R9, R10 and R18 are in the category of the insignificant risks. Risks R1, R2, R5, R13 and R16. But actually, all these conclusions could be made with the help of the risk matrix. The advantages of the risk map are connected with its flexibility. For example, if the project manager has significant reasons to change the boundaries between different risk categories, he or she can easily do it without the necessity to re-map the risks. The project manager can easily fine-tune the risk category boundary. For instance, the threshold between categories can be not 5 man-days, but 6 or 4 man-day. For changing the threshold the project manager can just change the position of the isorisk curve and see the result. In the case of the risk matrix the project manager has to change the whole risk matrix and introduce additional columns and rows into it.

Besides, it is not difficult to establish additional risk categories. If the project manager finds the necessity to distinguish all risks into four categories, he or she should define the boundaries between them. For instance, by depicting the isorisk curves associated with the thresholds of 5, 10 and 15 additional man-days the project manager can identify insignificant, controllable, dangerous and extreme risks as it is shown in Fig.2. If it is needed, the categories with different scope (different areas) can be introduced, so that the zone of controllable risks would be larger than any other zones.

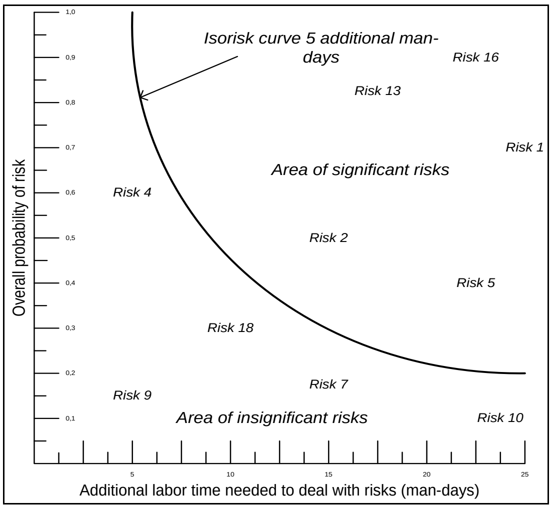

Fig.1: Example of the risk map with two risk categories

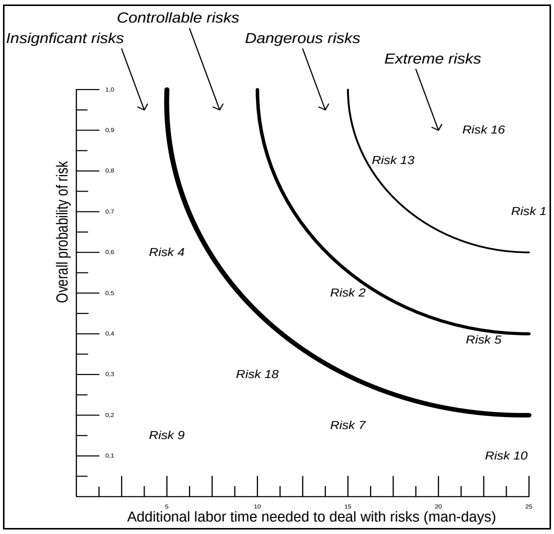

Fig.2: Example of the risk map with four risk categories

In order to introduce new and different terms of the scope risk categories in the risk matrix the whole matrix should be changed which can be very time-consuming task, especially in the case with big number of different project risks which is usually the case for engineering projects.

5 Summary

From the example above it is clear that the risk maps can be considered as more flexible and more robust tools for analysis and prioritization of project risks [9, 13–14]. The risk maps can be used instead of or in addition to the more traditional risk matrix. The risk maps seem to be especially useful for engineering projects which are characterized by the big number of various risks and very dynamic environments.

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