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Methodology Article

Risk Prioritizing Method at the Stage of Qualitative Risk Analysis in the Process of Project Implementation

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Abstract: Current trends in project management include risk management in the process of project implementation. After identifying the risks of the project, the task arises to identify the most dangerous risks for the project out of all numerous risks, in order to subsequently take planned actions to avoid them or reduce their impact. This objective – the task of prioritizing (ranking) risks – is reached at the stage of qualitative risk analysis. As a rule, the danger (importance) of risks is determined by the risk magnitude, which depends on the occurrence probability of a risky event and the impact of risk on the main target parameters of the project. However, due to the peculiarities of the methods of determining the amount of risk at the stage of qualitative analysis, the problems of prioritizing several risks having an equal amount of risk often arise. Moreover, there are no rules or recommendations on how to practically act in such cases and prioritization is carried out with a high degree of subjectivity. Therefore, the purpose of this study is to propose a new risk prioritization method that project teams could practically use at the stage of qualitative risk analysis in these cases. This improvement in qualitative risk analysis methods will expand the ability of project participants to manage risks, reduce subjectivity in decision-making and, accordingly, improve the quality of project implementation. To do this a risk prioritization method based on the use of the analytical hierarchy procedure proposed by T. Saaty is suggested. This method consists in decomposition of the problem to be solved – obtaining hierarchies, and synthesis based on either quantitative estimates or relative judgments. Additional parameters (criteria) are considered for implementation of this method that characterize the compared risks, as well as the value coefficients of these criteria in the overall assessment. Based on the estimates obtained for each criterion and each risk, an overall score is calculated taking into account certain weighting factors of the criteria for each risk. As a result, according to the estimates obtained, risks are prioritized. The use of such a procedure enables reaching a reasonable decision, obtained not by means of simple conclusions, but on the basis of comparative assessments of each risk. This, accordingly, reduces subjectivity of risk prioritization. The proposed method is described in detail in the article and can be used in real projects.

Keywords: Risk, Risk Analysis, Risk Prioritization, Criteria, Alternatives, Analytic Hierarchy Process (AHP)

1. Introduction

Almost all project managers are faced with the problem of risk management, since risks inevitably accompany any projects. Practices of the area of knowledge "Project Risk Management" are among the most frequently used ones in projects: around 97% of projects make use of risk management practices in one way or another [1] and these practices are completely used by 65% of projects [2]. It should be mentioned that the area of knowledge "Project Risk Management" is described in the global PMBOK standard in a very detailed way and it's clearly defined what a project manager and their team should do at various stages of the project lifecycle [3, 4]. Moreover, there is a Standard of the Project Management Institute (PMI) for Risk Management [5], which confirms the importance of this area of project management. However, it is not always obvious how to perform these practices, both to new project managers and the more experienced ones.

The stage of qualitative risks analysis includes the task of their prioritizing. This is the central task of this stage, since a fairly significant amount of different risks is determined in the process of risk identification. This number, depending on the project, can amount to dozens or even hundreds of risks, that can be classified according to various criteria into risk groups. In reality it is impossible to track such a number of risks and provide for their reflection. Therefore, in order to identify the most dangerous risks and provide possible response strategies for them, it is necessary to prioritize (rank) risks.

Risks are frequently prioritized according to risk magnitude, which is defined as risk probability and its impact on one or more project objectives such as duration, cost, content or quality. The probability and impact matrix is used to assess risks [3]. The probability of risk occurrence and its impact on the project parameters are determined by means of the given tool. Since the above tool has a very limited number of results, the task of prioritizing risks with the same risk level often arises. In this case it is advisable to compare such risks based on other criteria. However, the process of risks comparison with the same risk level is not specifically identified. For that reason decision-makers often build various logical chains in such a case guided by deductive methods, solving this multi-alternative problem intuitively. Moreover, such solutions may not lead to the correct decision since connections between different logical chains may be lost. This means that such decisions are subjective, made approximately, "by eye".

In order to make more informed decisions, with a lower level of subjectivity and, accordingly, to obtain the best solutions, it is recommended to use T. Saaty's method of the Analytical Hierarchy Process (AHP) [6]. This method is not a new one: it has been widely spread and is used in various fields of human activity – in politics, economics, trade, mathematical programming, science and technology, education, energy, investment, medicine, sports and many others [6, 7].

In fact, AHP is one of the most widely used multi-criteria decision analysis methodology around the world. Moreover, this method is actively developed. The multi-criteria decision-making community brings together thousands of scientists, educators and other professionals. The International Symposium on the Analytic Hierarchy Process (ISAHP) is held every two years. The International Journal of the Analytic Hierarchy Process (IJAHP) is published, as well as other specialized journals.

The development of the method is carried out in many directions, which can be conditionally reduced mainly to a modification of the method, obtained either by simplifying the computational procedures, or, conversely, by a more detailed calculation, which ultimately improves the accuracy and validity of the results [8]. Separately, one can single out the direction of the practical application of decision-making methods according to a variety of criteria in various fields of activity.

An extension of the classical AHP method was the Analytic Network Process (ANP) and a combination of these methods - AHP / ANP. The ANP method is also effective when there are dependencies between the selected criteria, or there is a situation of interaction between alternatives, in cases of a group decision. But, and these methods have their modifications. Some of them are aimed at reducing the participation of an expert in the decision-making process in order to make the choice more objective. Others allow taking into account the features of interdependence between objects, feedback, fuzzy data on alternatives, and more [8].

Great opportunities open up when artificial neural networks, artificial intelligence, are used as a network. This is a hybrid method - a combination of AHP and Artificial Neural Networks (ANN) - AHP-ANN. Using AHP with artificial intelligence has obvious advantages, as neural networks are adaptive and self-tuning. This allows problem solving in situations where pairwise comparisons, typical of AHP, may be subjective or imprecise [9].

It should be recognized that there are a fair number of those who criticize the AHP method. Basically, this criticism is based on the fact that the method does not have a rigorous mathematical justification, and there is no way to assess the reliability of solutions. There are examples of incorrect decisions. Therefore, other methods are proposed (for example, methods of the theory of multifactorial utility, Goal Programming, multi-objective mathematical programming and some others) [10] But, T. Saaty's method and its modifications are still popular and very widely used in the world.

Based on the AHP, decision support systems have been developed that allow obtaining quantitative estimates of the effectiveness of the functioning of the systems under study, which facilitates the activities of specialists and improves the quality of their work. With the use of these artificial intelligence systems, we can talk about intelligent decision support systems. [8]

Recommender systems are widely used, for example, when choosing movies to watch, music to listen to, news to watch, books to read, and restaurants to visit.

There are currently many AHP software packages to facilitate analysis (Goepel, Solutions, Expert Choice, MPRIORITY, Imperator). And, the SuperDecisions software developed by the Creative Decisions Foundation assists with ANP calculations and facilitates traditional AHP calculations [7, 11].

The task of risk analysis in various fields of activity can also be solved using the considered methods. As a rule, these are purely applied solutions [12-14].

Finally, very important applications of multi-criteria decision making methods are brought to the attention of H. Wallenius & J. Wallenius in their essay [15]. These are problems caused by global mega trends such as Internet search engines and recommendations, big data and artificial intelligence, the circular economy, climate change and environmental care. Achieving success in these global challenges can be achieved by developing new decision-making tools, software, and generating new ideas.

Keeping in mind all that has been said thus far, it can be stated that AHP enables choosing such an alternative in multi-criteria tasks that most fully complies with the specified criteria and thereby allows prioritizing alternatives.

This is precisely the reason for the expediency of using this method in the solution of our problem – addressing the task of risk prioritizing that have the same amount of risk.

Thus, the purpose of the given study is to develop and improve methods of qualitative risk analysis. Accordingly, the problem under study is the reduction of subjectivity in risk assessment at the stage of qualitative risk analysis.

Practical application of the risk prioritizing method with equal risk values using the Saaty procedure will be considered in the following sections in detail.

2. Description of the Proposed Risk Prioritization Method

Assuming there are four risks that, according to the results of the probability-impact analysis, have the same risk level (in different projects, this number can be any). Designate them as A, B, C and D. They are defined as alternatives according to Saaty's method.

As previously stated, in order to rank these risks, they must be compared with each other based on the other criteria. These criteria are recommended for analysis in the PMI Standard [5]. Although a project team can establish other criteria in each particular case, according to the peculiarities of the project, the following criteria are offered in the PMI Standard:

1) urgency (proximity);
2) manageability;
3) impact external to the project.

Urgency (proximity) refers to both proximity of risk appearance in time and the time required for its detection, as well as clarity of symptoms and warning signs (also referred to as detectability) that may precede the risk event. The time required for risk detection and detectability can also be applied, if necessary, as criteria by which risks are compared with each other. Nevertheless, we will make use of only one criterion, urgency, for the purpose of simplification in the given article.

Manageability criterion determines whether it is possible to influence this identified risk in any way at all or whether any actions are useless or extremely expensive.

While performing risk assessment based on the last, third criterion – impact on the other objects that are external to the project – it estimates the impact of identified risk on the other projects, on the institution implementing the given project, or another enterprise. (This criterion will be further referred to as "impact", for the purpose of shortening).

Thus, in order to compare competing risks the three criteria recommended in the PMI Standard [5] will be used.

The model of AHP method is based on hierarchy. For our example, we define:

Level 0: The goal is to rank risks of the same risk level after analysis according to the criteria of probability of occurrence and risk impact.

Level 1: Criteria – three criteria have been selected based on which competing risks A, B, C and D will be compared.

Generally, each criterion can have an unlimited number of sublevels – 2,3...n. But, for the simplicity of the example, we will limit ourselves to one level.

The next level is the level of alternatives and their assessment.

The AHP principle is based on linear convolution. For this it is necessary to determine the weight of the criteria and assess the alternatives. Along with that, the weight of the criteria and assessment of alternatives are obtained in a special way [16].

So, to implement the AHP method, it is necessary to obtain assessments of alternatives and weight of criteria. If alternatives have an objective assessment based on the criterion, these assessments are recorded in the table and normalized so that their sum is equal to 1.

If alternatives cannot have an objective assessment based on the criterion, it is recommended by Saaty procedure in this case to employ pairwise comparison of alternatives [6, 16] to simplify calculations. In our case it is impossible to provide objective estimation for all three criteria. Therefore, in order to get assessment of alternatives, it is necessary to conduct a pairwise comparison of alternatives.

To make such comparisons, it is necessary to develop a comparison scale. A scale of the following type is often used:

1 – equivalence;
3 – moderate superiority;
5 – strong superiority;
7 – very strong superiority;
9 – highest superiority.

Moreover, intermediate estimates can also be used for assessment – 2,4,6,8 [17].

In accordance with this scale, a pairwise comparison of alternatives is performed while the result of such a comparison is indicated in the table.

How can this practically be implemented for our alternatives – risks A, B, C and D? Let's assume that we are conducting a pairwise assessment based on the criterion "Urgency". Analyzing the risks (alternatives), we come to the conclusion that risk A is more likely to be expected earlier than risk B and this superiority is estimated as three to one. Let's write it down as follows:

A vs B – 3/1 and, accordingly, B vs A – 1/3.

While analyzing further the risks of the other alternatives based on the criterion "Urgency" and estimating their superiority in pairs similarly to the example given for all possible relationships, we can obtain the following results:

A vs C – 4/1 and C vs A – 1/4;
A vs D – 1/3 and D vs A – 3/1;
B vs C – 2/1 and C vs B – 1/2;
B vs D – 1/4 and D vs B – 4/1;
C vs D – 1/5 and D vs C – 5/1.

(It should be noted that the numerical estimates are made solely for example).

Then, indicating the obtained ratios into a table, we get the table of pairwise comparisons of alternatives for the criterion "Urgency" (Table 1):

Table 1. *Evaluation of "Urgency" criterion by the method of pairwise comparisons.*

	A	B	C	D
A	1/1	3/1	4/1	1/3
B	1/3	1/1	2/1	1/4
C	1/4	1/2	1/1	1/5
D	3/1	4/1	5/1	1/1

Then, for the convenience of calculations, simple fractions are converted to decimals (Table 2):

Table 2. *Evaluation of "Urgency" criterion by the method of pairwise comparisons in decimals.*

	A	B	C	D
A	1,00	3,00	4,00	0,33
B	0,33	1,00	2,00	0,25
C	0,25	0,50	1,00	0,20
D	3,00	4,00	5,00	1,00

Further, in accordance with Saaty procedure, row values are calculated (Table 3) and the table is normalized, for which the row value is divided by the total value (Table 4):

Table 3. *Calculation of row values.*

	A	B	C	D	Row value
A	1,00	3,00	4,00	0,33	8,33
B	0,33	1,00	2,00	0,25	3,58
C	0,25	0,50	1,00	0,20	1,95
D	3,00	4,00	5,00	1,00	13
Total value					26,86

Table 4. *Calculation of normalized row values.*

	A	B	C	D	Normalized row value
A	1,00	3,00	4,00	0,33	0,310
B	0,33	1,00	2,00	0,25	0,133
C	0,25	0,50	1,00	0,20	0,073
D	3,00	4,00	5,00	1,00	0,484
Normalized total value					1,000

The corresponding row values are understood as estimates of alternatives. Let us denote our estimates of alternatives as E_{Ji}, where:

j - is criterion number. For our example, the criteria "Urgency", "Manageability" and “Impact” will have indices, respectively 1, 2 and 3;

i - is the index of alternatives (A, B, C and D).

Therefore, the estimates of alternatives for criterion "Urgency" are as follows:

1) for alternative A: E_{1A} = 0,310;
2) for alternative B: E_{1B} = 0,133;
3) for alternative C: E_{1C} = 0,073;
4) for alternative D: E_{1D} = 0,484.

In the same way the estimates of alternatives for the other two criteria – "Manageability" and "Impact" – can be calculated for our example. Let's assume that as a result of such pairwise comparisons and corresponding calculations, the following estimates are obtained:

for criterion "Manageability":

1) for alternative A: E_{2A} = 0,354;
2) for alternative B: E_{2B} = 0,146;
3) for alternative C: E_{2C} = 0,224;
4) for alternative D: E_{2D} = 0,276;

for criterion "Impact":

1) for alternative A: E_{3A} = 0,236;
2) for alternative B: E_{3B} = 0,344;
3) for alternative C: E_{3C} = 0,238;
4) for alternative D: E_{3D} = 0,182.

All estimates for all three criteria will be recorded in Table 5:

Table 5. *Evaluation of alternatives for each criterion.*

	Urgency	Manageability	Impact
A	0,310	0,354	0,236
B	0,133	0,146	0,344
C	0,073	0,224	0,238
D	0,484	0,276	0,182

In accordance with the AHP procedure, the next step is to determine criteria weights.

Criteria weights are calculated based on a similar method, which was used to determine the above estimates – by pairwise comparison of the criteria. At the same time it should be understood that by conducting a pairwise comparison of criteria, we virtually establish a preference for one criterion over another. This is definitely a subjective action based on our idea of the "importance" of each criterion.

Suppose we assume that the criterion "Impact" has a slight preference over the criterion "Urgency" and a moderate preference over the criterion "Manageability", and the criterion "Urgency" is slightly preferable than the criterion "Manageability". These relations can be indicated as follows:

1) "Impact" vs "Urgency" - 2/1;
2) "Impact" vs "Manageability" - 3/1;
3) "Urgency" vs "Manageability" - 2/1.

Thereupon, having performed all the above actions, we will get normalized row values, representing the weights of our criteria (Wj):

1) for criterion "Urgency": W_1 = 0,308;
2) for criterion "Manageability": W_2 = 0,162;
3) for criterion "Impact": W_3 = 0,53.

Further, making use of linear convolution (weighted sum), we obtain an integral estimate of our alternatives - the importance function (F_i):

$$F_i = \sum_{j=1}^{n} W_J E_{ji}.$$

The calculations result in the following data:

$$F_A = 0{,}278;$$

$$F_B = 0{,}247;$$

$$F_C = 0{,}185;$$

$$F_D = 0{,}290.$$

Thus, the most significant alternative in our example is the alternative D, since the value of its importance function is higher than that of the other alternatives. Returning to the risks, this means that among the risks considered, having the same degree of risk, the most important is risk D. Ranking the remaining risks by the magnitude of the importance function, we obtain the following sequence (in decreasing order): risk A, risk B; and the least importance is attributed to risk C.

This outcome will enable the project manager to make the right risk management decisions during project execution.

Obviously, the proposed method can also be used to determine the magnitude of the risk and then all risks will be immediately ranked. However, the practicality of using this method should be taken into consideration since in this case the computational load in the project increases. Therefore in small and simple projects this may be unnecessary, while in complex demanding projects such use of the method will be justified.

3. Conclusion

The stage of qualitative analysis of risk management in a project includes prioritization (ranking) of the risks identified by the project team at the previous stage. To perform such ranking, it is recommended to employ a method that compares risks by the amount of risk, depending on the probability of occurrence of a risky event and impact of this event on the target parameters of the project. Practical use of this ranking method has shown that there are often situations when several risks have the same value of the risk magnitude. In such cases, it is recommended to compare risks by other criteria. However, there is no methodology for performing such a comparison. In such cases, the project team ranks the risks based on their own ideas and conclusions, which results is a very subjective risk assessment, which may be far from reality.

In order to eliminate these limitations of the existing risk assessment methodology at the stage of qualitative risk analysis in the process of the project implementation, this study was conducted. To prioritize risks having the same risk value, a method based on AHP, developed by T. Saaty, is proposed. AHP allows choosing the best alternative that would most fully satisfy the specified criteria in such a multi–criteria task as risk prioritizing. This will ensure that more informed and correct decisions are made in the project risk management process.

The proposed method of risk assessment and prioritization improves the existing method of risk prioritization assessment based on the risk magnitude criterion, eliminates its shortcomings and reduces the subjectivity of the decisions made. The proposed method does not completely eliminate subjectivism while prioritizing risks, but significantly reduces it due to the fact that criteria and weights estimates are not assigned arbitrarily, but are obtained either from objective estimates or by pairwise comparisons. The given method provides the project team with a practical tool for performing the stage of qualitative risk analysis while managing risks in the project.

In addition, this method can in some individual cases be used instead of the existing method to assess risk probability and impact.

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