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Review

Project Risk Management: Comparative Analysis of Methods for Project Risks Assessment

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A B S T R A C T

Analysis of project risks leads to a deeper understanding of potential problems in the course of the project. A number of techniques and tools are used to that purpose, which can ensure effective assessments both quantitative assessments and measures for every project risk, and qualitative assessment in order to sort project risks according to their rank and category. This article analyzes some of the methods from the aspect of their advantages and disadvantages in application with the aim to facilitate the selection of the most convenient method for the particular project. A comparison was made of the following methods: PERT, Brainstorming, Delphi, Monte Carlo, sensitivity analysis method, probability analysis method, and the Decision Tree. Comparative analysis of methods for the assessment of project risks include those variables that have a major impact on the cost, time, or benefits, on which the project is most sensitive to. It is based on the relation of a particular technique or tools towards the description of the risk, towards all possible outcomes of risk, magnitude or seriousness of outcome, probability of the appearance of the risk event, probability of the possible outcome, time of the risk event and the interaction of the outcome of the risk with other parts of the observed project or of other projects.

Key words*: project risk management, risk assessment, simulation*

Introduction

Risk analysis is a systematic process for assessing the level of importance of identified risks on a project. The steps in the risk management process according to the PMI methodology are risk planning, risk identification, qualitative and quantitative risk assessment, risk response planning, and also monitoring, controlling and reviewing of risks. Successful risk management requires a process of risk analysis based on a scientific approach with the support of qualitative and quantitative methods. Qualitative methods of risk analysis are used to determine the priorities of identified risks using the evaluation of the rate of their occurrence and impact on the project objectives, whereas the methods of quantitative risk analysis are based on numerical solutions. The processes of qualitative and quantitative analysis can be carried out simultaneously and they do not contradict each other.

Within the framework of qualitative methods, the comparative analysis of advantages and disadvantages in this article includes: Brainstorming, Delphi, Final project reports – lessons learned, Probability and Impact Matrix, AHP (Analytic hierarchy process) method and Root cause analysis of risk. The chosen methods of quantitative risk analysis are as follows: Sensitivity analysis method, PERT, Probability analysis method, Monte Carlo and the Decision tree.

The assumption is that the appropriateness of a certain method for the assessment of project risks on a particular project depends on the strengths and weaknesses of that method with regard to its implementation in the conditions related to certain types of projects. The assessment of strengths and weaknesses of methods for risk analysis enables the project team to quickly select a valid method which ultimately results in an improved risk management process on a project.

The goal of this research is to enhance the ability to manage risks on projects. The ability in this context includes methods, tools and techniques regarding the amplification of possibilities of risk management, and motivating people to increase the maturity of risk management on a project. Finally, the theoretical aim of this research is to contribute to the existing knowledge on managing uncertainties in project organization.

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In the analysis of project risks we are faced with the problem of choosing the appropriate method for assessing risks, and the ubiquitous demand for appropriate measures regarding project risks in case of their possible emersion, their consequences, their interrelations and the way the problem is perceived by the team, the organization and the public.

The objective of risk analysis is to obtain the risk profile of the project leading to the process of creating a response to that risk. The attained knowledge includes the probability of reaching a specific project outcome, the function of time distribution needed for the completion of the project, etc. In the process of obtaining responses to the risk, that knowledge will be used to define practical responses which allow project managers to mitigate risks by reducing the impact of risks on project objectives. Using the so called ranking indices, such as criticality or importance, it leads to the most suitable position for mitigating risk. Project activities and associated risks are ranked according to those indices, taking into account the impact they have on the project goals[1].

Comparative Analysis of Methods for Project Risk Assessment

Qualitative methodology with the tendency to study the benefits and impacts of the chosen methods for managing project risks, and perceiving opportunities for their optimal use has been used in comparing methods for risk assessment. The used information was based on the results of literature overviews, publicly available documents, such as project newsletters, project reports and project websites[2–8]. Based both on the theoretical and practical knowledge, an analysis of risk techniques that includes quantitative and qualitative methods for risk analysis was created. Characteristics relevant in the project risk assessment have been processed using a selection of methods and tools which was made by means of qualitative analysis.

The criteria for the comparison of tools and techniques for risk assessment in this study rely on the influence of certain techniques or tools on the description of the risk, all possible outcomes of risk, the magnitude or severity of the outcome, the probability of the appearance of a risk event, the probability of each possible outcome, time of the risk event during the project, and the interaction of the outcome of risk with other parts of the observed project or other projects.

The results of quantitative risk analysis can either be grouped within the existing (project customized) limits of cost risks, technical risks and schedule risks or analyzed by means of statistical tools. Unlike quantitative measurements and contrary to numerical indicators, qualitative risk analyses, where the »sense of the risks« and the awareness of the entire team about the potential risk events is valued, can be taken into account. During the execution of the qualitative analysis, risk ranking is used as an indicator of the potential importance of risk on the project. It usually serves as a measure of probability of the appearance of risk events and consequences of that event which is often expressed as low, medium and high (or possibly low, medium low, medium, medium high and high)[9].

Methodology for designing priority lists of risk varies depending on the method applied for risk assessment[1]. Using the Probability and Impact Matrix, ranking the level of risk will depend on the probability and consequences of the appearance of a risk event and possibly on the frequency of occurrence, impact time, and interactions with other risks. When using the Monte Carlo simulation in the cost risk analysis, the ranking may include the percentage of the proportion of risk cost at the desired level of confidentiality[10]. For the results of the Decision tree analysis that include the expected value, the ranking may simply be a list of outputs from the largest positive output to the smallest negative output [11]. Neither of these methods used for generating the priority list of risks is necessarily superior to the other, they are all potentially useful. The challenge in such cases is to effectively integrate the results of an analysis of what can be a diverse set of results in a priority list of risks. There is no optimal algorithm for achieving such a task that would be valid for all projects. Project managers should draw such a list agreeing on a structured evaluation of the results of a risk analysis and document their reasonableness to the fullest possible extent. Different outputs are possible both in the qualitative and quantitative risk analysis, and the most noteworthy of them are: risk ranking on the level of an entire project, a list of priority risks, the probability of project cost and / or schedule overruns, the probability of failing to meet project requirements, the results of the Decision tree analysis and the tactics of failure and impacts and the likelihood of failure[12].

Project teams use different tools for different risks: estimates for the material elements of a project, ranging from the largest estimated loss to the probable maximum loss, and actuarial projections for expected losses in cases where sufficient data on losses is available[13]. In continuation, we give an example of the Monte Carlo simulation in a case of insufficient data in terms of response to the question about the amount of investment. Probabilistic and quantitative risk assessments are used both for assessing the toxicity of drugs and chemicals[14], and as a support for making decisions in the field of public policies. Experts' qualitative analyses are mainly used for political risks. Financial risks rely on complex econometric models generally understood by team members who are trained in this area and by the initiators of projects. Quantitative tools are often incomprehensible to laymen, while qualitative tools lack the mathematical factor. A combination of qualitative and quantitative tools should preferably be used due to the fact that it can simultaneously lead to a sensitive and practical risk assessment.

The areas of knowledge on quantitative techniques are continuously enriched with new knowledge. The Monte Carlo simulation method forms part of the techniques dominant in both theory and practice. However,

many of the alternative techniques such as the sensitivity analysis method, probability analysis method, Delphi method, neural network, fuzzy logic, Decision tree – have facts and proven achievements in the practical application which gives room to mutual comparison[15].

Methods of qualitative risk analysis on a project

Methods of qualitative risk analysis on a project evaluate the features of each risk individually which enables the creation of a priority list of risks. Qualitative risk analysis includes an analysis of the probability of risks, their impact on the project objectives, an analysis of the causes of risk, the risk importance analysis, and drafting of the priority list of risks. It is necessary to choose the features that will define the importance of risk. In the process of data collection and analysis, various tools, such as interviews, workshops, and references to databases from previous projects, are used in order to evaluate the data. Furthermore, qualitative analysis of project risks results in prioritizing risks according to the probability of occurrence and the impact on specific project goals, and prioritizing risks according to the probability of occurrence and the impact on the overall project objectives. The categorization of the causes of risks is as important as documenting the results of the qualitative risk analysis on a project.

Brainstorming – free succession of ideas

Brainstorming is widely used in the formative planning of a project, and can be very useful in identifying risks and creating risk scenarios for the project in execution. It is a simple yet effective incentive for people to think creatively in a group setting without emotional blockage or criticism from other members of the group. Everyone is invited to present their review of the ideas expressed, while verbal or non-verbal dissent or criticism is not allowed. The intention is to encourage as many new ideas so some of them may serve as triggers for even better ideas.

The benefits of Brainstorming lie in the fact that it allows all stakeholders to contribute to the risk analysis with their knowledge and experience, and in ensuring conditions for creative generation of ideas while the description of risks can always be complemented by the newly-imposed knowledge[9].

However, the lack of quantitative results can be a weakness of this method when we require a calculation of the probability of a risk event emerging, the probability of each possible outcome or accurate estimation of the time when the risk events hold occur.The downsides of this method are reflected in the organization of work meetings at which key stakeholders should be present and the cost that such organization presupposes. Furthermore, there is a risk of being subjected to group think and group dynamics, or possible connivance of authority e.g. management. A badly prepared meeting may lack in desired effects and results. The results of Brainstorming often need to be verified and filtrated in cases where the identified phenomena do not correspond to risks or if the same statements are repeated. Accordingly, it is preferable to count with the presence of key stakeholders, good preparation of working meetings and structured approach such as the use of structured risk analysis – RBS (Risk Breakdown Structure).

Delphi method

The basic idea of the Delphi method is for a group of experts to reach a consensus on the best solution for a particular problem. This is particularly useful in assessing potential risk events in the emerging activities in which the influence of risk is of key importance. It is of uttermost importance to choose the leading experts in a particular field, preferably experts that are not acquainted, and to organize consultations with them on different locations[16].

The features of the experts opinions, such as different responses and individual emotional attitude, point to the need for an »expert divergence« base[17].

Results, opinions and estimates are evaluated and processed statistically, and the outcomes of these operations are submitted to each participant. The process is repeated iteratively until the best solution for a given problem is reached.

The advantage of the Delphi method in decision-making is that it reaches expert opinions without high cost sand in a relatively easy manner. The Delphi method analyses are prolonged, which is one of the limitations of this method. Time is spent on activities such as sending letters, waiting for everyone's responses, copying and resending replies and repeating this process until a consensus is reached[9]. It is advisable to choose another risk analysis method for decision-making in emergency situations or whenever time plays an important role.

Weaknesses of the Delphi method are manifested through the limitations of its application on technical risks and the dependence of the actual competence of experts. Furthermore, the method may take longer than anticipated depending on the experts' iteration input.

Final project reports – lessons learned

There is a lot to be learned about the risks of a certain project based on final reports which can serve as the implementation of the lessons learned technique when a greater gained experience entails knowledge of possible risk events and is applied to the project in progress[17]. The advantage of this method lies in time saving when using previous experience. Moreover, it prevents repetition of the same mistakes or of letting the same opportunity slip, while simultaneously improving the process of maintaining institutional ownership. Using final reports as sources of information in assessing project risks has its weaknesses when the information is incomplete. In that case, details regarding past risks may not include all the relevant details for the successful resolution of current risks, and ineffective strategies are rarely documented. Another weakness of final reports, as the basis

for project risk assessment, is that they are limited to those risks that have previously occurred.

Probability and Impact Matrix

Rules for risk ranking are often already included in the existing organizational resources due to the fact that experts have specified and thus documented them in advance. They are specially adapted to each specific project in the planning process of risk management. The Probability and Impact Matrix is used to evaluate the importance and prioritization of each risk[1]. Risks can be individually ranked for each of the project objectives, and, in case of general ranking, the advantage among project objectives is easily visible which indirectly makes objective-related risks easily ponderated.

The positives of the Probability and Impact Matrix:

- it allows prioritization of risks for further use in the risk management process (e.g. in quantitative analysis or planning risk responses),
- it reflects the level of risk tolerance.

The fact that the Probability and Impact Matrix does not directly deal with other factors such as urgency which can partly affect risk ranking is one of the weaknesses of this method. Another drawback is that the range of uncertainty in assessing risk probability and impacts may exceed the predicted limit.

Given its constraints, the Probability and Impact Matrix should be used with caution in order to avoid erroneous conclusion. Such matrices are generally upper triangular, and not the mirror image of lower triangular as defined by a line drawn from the source to the location of maximum probability and impact. The incentive for using a symmetric boundaries appears in case of a risk event with the lowest probability of occurrence and the highest impact in case of implementation of the same, and so the risk level is classified as medium risk, not low risk. In addition, one of the weaknesses is that the possibilities or opportunities (»good risks«) require different ranking of consequences than risks (»bad risks«). It is unclear what such ranking should represent given that there is no unique definition for opportunities as well as for the associated consequences. There fore, the very nature of the opportunity matrix is problematic because of the fundamental difficulties in determining dimensions of the result, which can lead to erroneous results[9].

In case of equal values in the matrix, the prioritization is not entirely effective. Such cases require additional efforts in prioritizing.

AHP (Analytic hierarchy process) method

The AHP is primarily a method of decision-making that works by developing a hierarchical model of decision-making problems with the aim of selection, with criteria and alternatives. Comparisons between the relative importance of elements of the AHP model vary according to the intensity of importance: very important, moderately important, strictly important, very strictly important and extremely important[11].

In the process of assessing project risks, the positive side of the implementation of the AHP method is that it can help determine the relative weight of project objectives which affects the setting of priorities in terms of time, cost, scope and quality of project implementation. In addition, it helps develop the priority list of project risks as a whole on the basis of risk priorities related to individual project goals. On the other hand, the weaknesses of AHP occur in situations in which individuals may or may not agree with the project objectives and the decisions made by the management. In the process of risk analysis based on the AHP method, it is preferable to use experts' help, to reach an agreement on objectives' priorities on the managing level and to use proper tools and software.

Root cause analysis of risk

Root cause analysis of risk deals with the identification of the main causes of risk that can be seen as symptoms or as the underlying drivers of risk. It can identify common sources of risk and lead to a wide range of responses to risks[9]. Special attention should be paid to distinguishing between risks whose impact has an unspecified cause and those with a specific cause.

The positives of the Root cause analysis of risk are:

- it enables identification of additional, subsidiary risks,
- it enables the identification of risks that may be linked because of their common cause,
- it is the basis for the development of preventive and comprehensive responses,
- it can be used to reduce apparent complexity.

The weaknesses of the Root cause analysis of risk are:

- most risk management techniques deal with each risk individually, which is not suitable for establishing the cause of risk,
- it can simplify and hide the existence of other possible causes of risk,
- there may not be a valid strategy to address the root cause of risk that would be available after the risk had been identified.

Root cause analysis of risks how the possibility of effective identification of causes of risk in cases where risk originates from several basic causes.

Methods of Quantitative Risk Analysis on a Project

Methods of quantitative risk analysis are used on projects in order to develop numerical models, combine outputs i.e. project deliverables, utilize sensitivity analyses, and prepare and update priority lists of risks. Project deliverables referring to possible effects of risk may be anticipated by using techniques of quantitative risk analysis on a project. The features of techniques of quantitative risk analysis on a project include a comprehensive presentation of risks, budget related to the impact of risk,

appropriate quantitative methods for risk analysis, data collection tools, effective presentation of quantitative analysis' results, iterative quantitative risk analyses, and information needed for planning responses to risks[18]. Modeling techniques include the sensitivity analysis, the expected value analysis and simulations[20].

By using quantitative methods such as the Monte Carlo simulation, project risk analysis can provide a more realistic cost and schedule estimates than the non-probabilistic approach which assumes that the duration of activities and the amount of expenses are deterministically fixed[19]. Some projects do not require quantitative risk analysis, thus on smaller projects, for example, the qualitative analysis provides enough information for the selection of appropriate responses to risks. Partial risk analyses, such as qualitative analyses that assess risks individually, do not depict the overall risk of the project in its entirety while quantitative analysis does[21].

Project risk simulation methods

In terms of project management, simulation depends on two models: the model of defining project deliveries and outcome values, and the model of selecting techniques that generate multiple scenarios with repetition[21]. In simulation, we need to predict the behaviour of variables whose value cannot be determined (stochastic variables). This is achieved by generating value from their probability distribution. The information on probabilities is used to build a simulation model and to analyze simulation results. For the distribution of probability of the observed variables it is necessary to: gather information about the values of the stochastic variable, group values in intervals and develop a histogram of relative frequencies, and analyze the relative frequency histogram in order to verify to what extent the shape resembles some of the well known probability distributions. The type of probability distribution can be verified by using correlation tests, such as Kolmogorov, Smirnov, Pearson, and by measuring the correlation between theoretical and actual distribution of values obtained from previous analyses or expert estimates.

A decent system model is required in order for the system analysis to be properly carried out by means of any simulation methods. Without the proper model, the simulation results will not present the system operation.

Sensitivity analysis method

Sensitivity analysis finds a way of establishing value in case of any alterations related to an individual variable, and analyzes the impact of these alterations on the project. It is considered one of the simplest forms of risk analysis. Uncertainty and risk are reflected through a number of possible variations for each component of the original assessment. In practice, such an analysis is performed only for those variables that have major impact on the cost, time or profit, and to which the project is most sensitive. Sensitivity analysis is based on identifying critical parameters of the project. It includes all possible values of these parameters in a given time interval as well as the assessment of project efficacy in case of applying possible values of critical parameters[9].

Some of the advantages of the sensitivity analysis are reflected in the fact that it can have numerous possible outcomes, and a more realistic, but possibly more complex decision-making. It analyzes the impact of potential adverse changes in key variables. It assesses whether the decisions on the level of the entire project will be affected by these changes. It identifies activities that could mitigate possible negative effects on the project. It is important when many of the numbers that we use are subject to measurement errors and other sources of uncertainty. It helps understand the model better.

The relative importance of each verified variable is easily visible. The visibility of the maximum or minimum value of the critical parameter justifies the financial investment and ultimately points to the eligibility of the project's implementation.

Some of the weaknesses are: dealing with each variable individually, limiting the span of the assessment of variables' combinations as the sensitivity diagram gives no indication of the expected probability of occurrence. The disadvantages are also evident in the relatively complex computational procedure and the lack of influence of subjective opinions on the risk event.

PERT

The PERT (Program Evaluation and Review Technique) method estimates uncertainty from three aspects: optimistic, pessimistic, and realistically possible. The probability of achieving project objectives (time or costs) is obtained by observing activities on the critical path. Different results in terms of accuracy can be obtained by using different probability distribution curves such as beta, normal or triangular curves. Specific project requirements are reflected in dealing with risks which affects the choice of the method. PERT is one of the network diagram methods which are mainly used in large-scale projects[21].

The positives of methods such as network diagram are:

- The project team is focused on detailed planning since the development of a network diagram is a demanding job. During this process many hidden interdependencies come to light. Many project risks can be discovered.
- There is an increased probability of meeting milestones due to the fact that the method itself requires statistical evaluation of each task's fulfillment capabilities as well as other alternatives.
- The possibility of assessing variations and the »what if« scenario simulations enables the operation of the function for the evaluation and actualization of the implementation of contingency scenarios.

In terms of meeting various requirements of the project as well as working with risks, the PERT method has a number of limitations. The main problem is associated

with the prediction accuracy of the most optimistic (the most pessimistic) event and the likely duration of the activities. Another problem relates to the dependence of accurate results on the existence of the dominant pathway in the observed network. In case of multiple parallel paths in the network, an exceedingly optimistic estimate occurs. The PERT model is a suitable tool for a quantitative risk analysis in case of accurate assessments of the optimistic, pessimistic and most probable duration of activities as a result of reliable historical data, while keeping the dominant path in the network evident.

Some of the techniques and tools used by the PERT method are fast and easily provide insight into project risks. Others provide real benefits in risk management but also require greater effort and expenses. The most important advantage of the PERT method is reflected in the graphic display and easily visible contradictions between the deterministic appearance of the timetable created from the nodes on the critical path and the range of possible end points and their associated probabilities generated from the PERT analysis. Furthermore, PERT tools using Monte Carlo simulation techniques provide realistic timetables in cases with multiple critical paths[20]. Some PERT analysis tools allow project branching and analyses such as the Decision tree.

The extra effort and time invested in collecting valid input data for the PERT analysis may be perceived as aggravating circumstance. Apart from that, the illusion of high-accuracy output data (which cannot be more precise than the input data) arises from a large number of decimals generated by various software applications.

Probability analysis method

Probability is the occurrence of an event in a given time period. It ranges from zero (the event is unlikely) to one (the event is certain). The ratio of the number of favourable events to the number of all possible events results in the probability of an event[15].

The goal of the probability analysis is to predict all the possible probabilities of the project progress. Probability analysis goes beyond the limitations of the sensitivity analysis by specifying probability distribution for each variable individually, and then considering situations in which the values of all or only some variables can change. Probability analysis calculates:

- arithmetic means, standard deviations and variances of activity duration for each activity based on the predefined distribution,
- the expected value for the project, as the sum of the individual mean values,
- variances of the project as sums of the individual variances of the project, and the standard project deviations as the square root of the total variance of the project.

Probability distributions can be: normal, exponential, Weibull, Poisson, binomial, gamma, beta, t-distribution, Pareto, etc.

This method has been criticized as unfavourable in cases of accidents in complex systems due to its linear approach to events, while non-linearity and indirectness are precisely the features of crisis cases[23].

The possibility of rapid changes in the political and marketing environment makes it difficult to determine the probability of occurrence of certain variables. Probability analysis is not suitable for all project parameters. Different analysis methods are appropriate for the duration of project activity, but, for the cost per activity, the probability analysis can provide satisfactory quantifications and risk analyses on all levels of the project.

Monte Carlo

One of the major challenges in project risk management is assessing and modelling uncertainty in the duration of activities and the amount of costs. It is often assumed that the duration of an activity ensues from the distribution that includes all of the uncertainty arising from the realization of the risk. In this case, risk assessment is reduced to the distribution of parameters of activity duration estimates while ignoring the causes of risks and the dangers they represent. This approach is referred to as the activity-based approach. On the other hand, the approach based on actual risks assumes that all dangers originate from risks. An integrated approach in the Monte Carlo simulation relies on the evaluation oft he impact of risk on the duration of activities and the time of project completion[19].

In risk analysis, the Monte Carlo method simulates the intensity of the impact of identified risks and the range of possible outcomes for a number of scenarios. Furthermore, using random numbers, the Monte Carlo simulation method offers a powerful and easy way of including data related to probabilities[22].

The result of the Monte Carlo simulation is a probability distribution of possible outcomes. In this way, the Monte Carlo simulation provides a comprehensive glance at what can happen as well as the dimension of probability of that happening. The main advantage of the Monte Carlo simulation is that it helps incorporate risks and uncertainties to the process of developing project schedule. The Monte Carlo method is suitable for assessing the duration of the project.

It has a number of advantages compared to the deterministic or »single-point« risk assessment that are presented in the form of:

- probabilistic result – the results show not only what could happen, but what the probability of each outcome is,
- graphical output – perfect for commenting results with other stakeholders,
- sensitivity-good visibility of the correlation of the input data to the result, while deterministic analysis shows which variables have the greatest impact on the outcome less clearly,
- analysis scenario – the realization of different scenarios can be accurately observed according to the

input data, while the deterministic models make it difficult to see different combinations of values for different inputs and see the effects in different scenarios,

– correlation of inputs – it is possible to obtain a model of interdependent relationships between the input variables[1].

One of the advantages of the Monte Carlo method lies in its »brute force« approach which helps solve problems in cases in which it is not otherwise possible.

In addition, we shell stress the following advantages:

– It is primarily used in the analysis of risks related to schedule and cost of the project in order to assist strategic decision-making.
– It allows simultaneous change of all identified risks.
– It makes a quantitative assessment of the overall risk of the project. It reflects the reality of the appearance of several simultaneous risks during the course of the project.
– It provides answers to questions such as: (1) How probable is the initial plan's success? (2)How high a crisis factor, regarding time and costs, is tolerable to achieve a desired level of security?(3) Which activities are important in determining the overall project risk?

Important weaknesses are:

– Schedules are not simple and cannot generally be used in the simulation without the planning experts' intervention in form of significant removal of errors.
– The quality of the input data is highly dependent on expert judgment and the efforts and expertise of the person acting as the risk analyst.
– Management sometimes resists tools such as simulation because it considers them unnecessary and too sophisticated compared to traditional tools.
– The Monte Carlo simulation requires specialized software that must be accepted and learned (because if not, that can represent an obstacle in its use).
– It provides unrealistic results when the input data simultaneously contain threats and opportunities.
– It requires the use of special software in complex situations.
– Resistance may occur towards the use of the Decision tree analysis, as a technical approach of decision making[1].

Decision tree analysis

Decision tree risk analyses are usually carried out using specialized software whose features are distribution and availability. The software allows the user to determine the structure of the decision by using decision nodes, opportunity nodes, costs, benefits and possibilities. In addition, it is possible to verify different decisions in two ways: by using linear functions on the basis of expected value or nonlinear auxiliary functions of different forms[12].

The features of the Decision tree analysis are:

– Risk is treated as a side effect of a certain activity.
– The choice of model for analyzing risk depends on the decision-maker, who is then responsible for the shortcomings of the chosen model and the consequences arising there from.
– Probabilities and tendencies regarding the desired achievements, so, apart from real data, one works with assumptions, intuitions, speculations and subjective assessments.
– Chosen alternatives cover the same goal or problem.
– The decision maker associates profit and costs to individual alternatives, which points to their attitude towards risk.
– There is a possibility of analyzing as many aspects of risk as the decision-maker wants.
– It takes the interaction of people with the source of risk into account.
– The most appropriate method can be used for each problem.
– The existence of probabilities and tendencies regarding the desired achievements relative to the risk requires knowledge of the business environment related to risk in terms of social approach to risk analysis.

Recognized disadvantages of this method are:

– It is sometimes difficult to structure decisions.
– It can be difficult to quantify the probability of the risk event if there is no information on similar experiences from previous projects.
– The best decisions can be changed under the influence of plausible changes in the input data, which means that the response cannot be stable.
– Avoidance of decision-making on the basis of expectations of linear gain due to the existence of additional non-linear functions, which are sometimes difficult to specify.

A good and comprehensive Decision tree structure is important in order to carefully premeditate all alternatives solutions. Furthermore, credible data on probabilities, costs and benefits regarding decisions should be taken care of, and the use of auxiliary functions authorized by decision makers[1].

The Decision tree analysis helps in the calculation of the expected value of the project, in identifying alternative solutions on the project, and in choosing better direction for emerging actions. Furthermore, the Decision tree analysis is useful in situations that require discrete estimates. In more complex situations, it is recommendable to use simulations such as Monte Carlo or others.

Discussion on the Comparison of Methods for Assessing Project Risk

One thing that all these methods have in common is the basic idea which we can express with the »loss« x »probability« formula. On projects, »loss« is measured through its impact on time, money, and other related factors of the project. These two parameters characterize risk and must be assessed for each identified risk on the project.

Assuming that the statistical distribution presents the rank of opportunities for the duration or cost of a certain activity on the project, standard deviation or variance is the measure of risk. Larger rank for distribution entails a greater probability of risk for a given activity. In assessing risk for a specific cause, it is not necessary to use computers for simulations or modelling. However, if we are dealing with various activities or an entire project, the computer simulations are indispensable. The impact and probability of every project risk should be evaluated. Qualitative analysis is useful in the process of prioritizing risks. Quantitative analysis techniques should be applied to significant risks. Methods that use diagrams in their display, such as the PERT method and the sensitivity analysis, can use quantitative estimates as a qualitative indication of the order of impact magnitude of risk. Furthermore, qualitative analysis can, by means of simulation models, identify a specific scenario in which the realization of the risk event is possible. If we decide to use the PERT analysis, it is advisable to keep it simple. One of the advantages of simulation methods consists in the fact that they represent a powerful testing tool which can, at a lower cost and in a safe environment, develop appropriate responses to risks, while their effectiveness can be tested for all the impacts of a risk event prior to their inclusion. In addition, the simulation models are an effective tool in monitoring and controlling risk, and the implementation of risk response can be monitored as well[18].

Conclusions and recommendations

Project risk management is an important area within project management. Methods for risk analysis are part of the entire risk management process. During the risk management process, a number of risks that need to be assessed are identified. The analysis of project risks uses many different methods and techniques, and the cross-section of representative methods and techniques together with their strengths and weaknesses highlight the opportunities for their effective implementation in practice.

The appropriateness of a certain method for assessing project risks for a particular project is emphasized based on the theoretical and practical knowledge of the methods for the analysis of project risks and by structuring their strengths and weaknesses with respect to the use in conditions specified by the type of project. Understanding the strengths and weaknesses of methods for assessing project risks contributes, on one hand, to the decision on selecting a method that best suits the requirements of a particular project and, on the other, enables us, in the implementation of a particular method, to act so as to potentate strengths and find solutions for weaknesses.

Quantitative risk analysis can be successful in cases with realistic cost estimates and a realistic estimate of the time required for performing activities on a project. Furthermore, it gives good results when schedules are fully connected and adequate, and when comprehensive risk registers which include realistic assessment possibilities, and time and cost impacts of risk are made. Experienced stakeholders can provide estimates on three levels (optimistic, probable and pessimistic) of all the certain costs and time estimates. Quantitative analysis will be of no use if there is no schedule or cost estimate. Without that, all the risks and uncertainties cannot be defined in detail. In cases where stakeholders have certain conflicting goals on the project, negotiations may be prolonged due to seeking compromise solutions. Such solutions might not be optimal but may only serve their purpose. Political or other risks could have immeasurable costs and indefinite duration.

Neither method can cover all the risks. Each requires a detailed knowledge of the process and an accurate record of the observed processes. Risk assessment is not a non repetitive task – risk changes over time. Risk assessment has its own financial weight and, consequently, adequate proportional benefit must exist.

The project team should be open-minded and flexible in recognizing situations where qualitative analysis is not sufficient for a thorough description of risks needed in order to find the appropriate risk response strategies. If additional analysis is needed, the team can carry out a quantitative analysis instead of or along with a qualitative analysis.

When using the Brainstorming method, it is advisable to include all stakeholders in the debate, to make a good preparation, to structure risks, and to provide support. When using the Delphi method, it is advisable to throw out the unnecessary details, to select experts carefully, and to clearly define the scope. When using final project reports, it is necessary to be fully aware of the importance of prior experience. With the Probability and Impact Matrix, one should ensure that the input data is clear and unambiguous in determining the level of probability and impact, and should be careful to evaluate the combination of probability and impact which meets the conditions of low, moderate or high risk, so that the method reflects the organization's attitude towards risk. Furthermore, the level of influence of risk (low, medium, high), as perceived by the management or stakeholders, should be defined for each goal so it reflects the support of the organization.

The AHP (Analytic hierarchy process) method will be successfully implemented if it has an expert team leader and an agreement with the management about the development of a consistent set of priorities among the project

objectives and the application of appropriate tools or available AHP software.

The root cause analysis of risk works well in habilitating the identification of risk when risk is a consequence of the various underlying causes, and in exploiting the management's willingness to accept and deal with the cause of risk rather than to accept partial and indirect solutions.

Given that there is no structured procedure for conducting sensitivity analyses, it is advisable to rely on common sense and creativity, and to approach a problem from various aspects such as risk data or the probability of initiating a risk event. It is useful to change the elements of a problem in order to see how it changes the outputs.

The PERT method is suitable for major projects. It is advisable to devote additional effort and time to collect valid input data for a PERT analysis.

The weak point of the probability analysis lies in the risk assessment for the duration of project activities, so it is better to avoid it in such cases. However, satisfactory quantification of costs per activity is obtained using the probability analysis for risk assessment.

The Monte Carlo method requires designing of a good project model. It is advisable to use the abbreviated forms of the model, such as the project schedule and cost estimates. The method requires access to quality risk data regarding the impact of risks on parts of the project, on indefinite duration of activities and on uncertain costs of parts of the project. The credibility of the model depends on the quality of the data collected. Furthermore, it implies the use of correct simulation tools.

The Decision tree requires paying attention to structuring. Optimally, one should consider all known alternative decisions. The Decision tree should be entirely defined. Furthermore, it is advisable to ensure the availability and understanding of the specialized software needed for the structuring and implementation of a Decision tree.

Risk analysis should be carried out several times during the project development. The profile of project risk evolves and changes during project development when new knowledge is acquired and when changes arise in the execution of the project, while risk response strategies are implemented and monitored.

REFERENCES

1. PMI. (2009), Practice Standard for Project Risk Management. — 2. Intelligent energy projects search result, accessed 17.10.2012. Available from: URL: www.eaci-projects.eu/iee/page/Page.jsp?op=project_list&searchtype=3 — 3. Copernicus projects, accessed 17.10.2012. Available from: URL: www.copernicus.eu/pages-principales/projects/other-fp7-projects/marine/. — 4. US ARMY CORPS OF ENGINEERS, Project Costs and Schedule Risk Analysis, accessed 17.10.2012. Available from: URL: www.data.lca.gov/Data1/Volume%20III%20Atchafalaya%20Final/appendices/Appendix%20P%20Risk%20Analysis%20ARTM%2009232010.pdf. — 5. www.ce.utexas.edu/org/ccis/a_ccis_report_31.pdf. — 6. WALEWSKI J, GIBSON EDWARD G, International Project Risk Assessment: Methods, Procedures, and Critical Factors, accessed 17.10.2012. Available from: URL: www.netl.doe.gov/technologies/coalpower/futuregen/EIS/FG%20Risk%20Assessment%20110807.pdf. — 7. BRYANT M, CHARLENE REED A, Risk Report & Papers, accessed 17.10.2012. Available from: URL: www.riskworld.com/Nreports/NR5ME001.htm. — 8. TECHNEAU, Risk assessment case studies: Summary report, accessed 17.10.2012. Available from: URL: www.techneau.org/fileadmin/files/Publications/Publications/Deliverables/D4.1.5g.pdf. — 9. KERZNER H, Project Management – A Systems Approach to Planning, Scheduling, and Controlling, Tenth edition, The International Institute for Learning New York (John Wiley & Sons, New York, 2009). — 10. LEBRETON J M, PLOYHART RE, LADD RT, Organ Res Methods, 7 (2004) 258. — 11. KENDRICK T, Identifying and managing project risk: essential tools for failure-proofing your project, (AMACOM – American Management Association, 2003) — 12. HILLSON D A, Managing Risk in Projects (Farnham, Surrey, UK Gower, 2009). — 13. BRATU M, Annales Universitatis Apulensis, 13 (2011). — 14. MCALLISTER L B, The Use of Risk Analysis Techniques to Determine the Probability of Producing Non-Compliant Drinking Water: Focusing on Dual Media Rapid Gravity Filtration, (Waterloo, Ontario, Canada, 2006). — 15. KRANE H P, ROLSTADÅS A, OLSSON NOE, Project Organisation and Management, 3 (2011). — 16. WANG WT, KO NY, J Inf Sci, 38 (2012) 423. — 17. LYONS J, Leadersh Manage Eng 8 (2008) 231. — 18. CREEMERS S, DEMEULEMEESTER E, VAN DE VONDER S, A new approach for quantitative risk analysis, (Faculty of Business and Economics, Leuven, 2010). — 19. HOPKINSON M, Risk Management Capability (Gower Pub Co, UK, 2011). — 20. RODRIGUES A, Risk Manag Int J, 12 (2011) 34. — 21. OWENS J, AHN J, SHANE JS, STRONG KC, GRANSBERG DD, Public Works Manag Policy, 17 (2012) 170. — 22. FIELD A, MCKNEW M, KIESSLER P, Cornell Rest A, 38 (1997) 68. — 23. RAMANA MV, Bulletin of the Atomic Scientists, accessed 17.10.2012. Available from: URL: www.thebulletin.org/beyond-our-imagination-fukushima-and-problem-assessing-risk-0.

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UPRAVLJANJE PROJEKTNIM RIZICIMA: KOMPARATIVNA ANALIZA METODA ZA PROCJENU PROJEKTNIH RIZIKA

S A Ž E T A K

Analiza projektnih rizika vodi dubljem razumijevanju potencijalnih problema na projektu. U tu svrhu koriste se mnogobrojne tehnike i alati kojima se mogu osigurati učinkovite procjene – kvantitativne procjene i mjere za svaki projektni rizik i kvalitativne procjene za svrstavanje projektnih rizika prema rangu i kategoriji. U ovom radu su analizirane neke od metoda s aspekta prednosti i nedostataka u primjeni s ciljem olakšavanja izbora metode koja bi bila optimalna za određeni projekt. Uspoređene su metode: PERT, Brainstorming, Delphi, Monte Carlo, metoda analize osjetljivosti, metoda analize vjerojatnosti, te Stablo odluke. Komparativna analiza metoda za procjenu projektnih rizika obuhvaća one varijable koje imaju velik utjecaj na troškove, vrijeme ili ishode, a na koje je projekt najosjetljiviji. Temelji se na odnosu pojedine tehnike ili alata prema opisu rizika, prema svim mogućim ishodima rizika, magnitudi ili ozbiljnosti ishoda, vjerojatnosti pojave rizičnog događaja, vjerojatnosti svakog mogućeg ishoda, vremenu rizičnog događaja, te interakciji ishoda rizika s drugim dijelovima promatranog projekta ili drugim projektima.