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RISK MANAGEMENT MODEL IN SURFACE EXPLOITATION OF MINERAL DEPOSITS

MODEL ZARZĄDZANIA RYZYKIEM W EKSPLOATACJI ODKRYWKOWEJ ZŁÓŻ SUROWCÓW

Risk management is an integrative part of all types of project management. One of the main tasks of pre-investment studies and other project documentation is the tendency to protect investment projects as much as possible against investment risks. Therefore, the provision and regulation of risk information ensure the identification of the probability of the emergence of adverse events, their forms, causes and consequences, and provides a timely measures of protection against risks. This means that risk management involves a set of management methods and techniques used to reduce the possibility of realizing the adverse events and consequences and thus increase the possibilities of achieving the planned results with minimal losses.

Investment in mining projects are of capital importance because they are very complex projects, therefore being very risky, because of the influence of internal and external factors and limitations arising from the socio-economic environment. Due to the lack of a risk management system, numerous organizations worldwide have suffered significant financial losses. Therefore, it is necessary for any organization to establish a risk management system as a structural element of system management system as a whole.

This paper presents an approach to a Risk management model in the project of opening a surface coal mine, developed based on studies of extensive scientific literature and personal experiences of the author, and which, with certain modifications, may find use for any investment project, both in the mining industry as well as in investment projects in other areas.

Keywords: Risk, risk management, model

Zarządzanie ryzykiem stanowi istotny element zarządzania projektami wszelkiego typu. Jednym z głównych zadań w ramach studiów przed-inwestycyjnych i przy opracowywaniu dokumentacji projektowej jest zapewnienie maksymalnej możliwej ochrony projektu przed ryzykiem. Dlatego też zapewnienie i regulowanie informacji o zagrożeniach umożliwia określenie prawdopodobieństwa wystąpienia niekorzystnych zjawisk, ich formy oraz skutków, tym samym zapewniając możliwość podjęcia odpowiednio wczesnych kroków zabezpieczających. Oznacza to, że zarządzanie ryzykiem wymaga zastosowania różnorakich metod i technik zarządzania aby obniżyć prawdopodobieństwo wystąpienia niekorzystnych okoliczności wraz z ich skutkami, a zwiększyć szansę osiągnięcia założonych celów przy minimalnych stratach.

Inwestycje są kluczowym elementem w przedsięwzięciach górniczych, w większości są to bardzo złożone i ryzykowne projekty, z uwagi na oddziaływania czynników wewnętrznych i zewnętrznych oraz z uwagi na różnorakie ograniczenia społeczne i środowiskowe. Wiele firm na świecie poniosło poważne

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straty finansowe z powodu braku systemu zarządzania ryzykiem. Systemy zarządzania ryzykiem są niezbędne w firmach i powinny zostać wprowadzone jako element struktury całościowego systemu zarządzania.

W pracy tej omówiono zastosowanie modelu zarządzania ryzykiem w projekcie obejmującym uruchomienie odkrywkowej kopalni węgla. Model został opracowany na podstawie danych literaturowych oraz w oparciu o doświadczenia zawodowe autorów. Po odpowiednich modyfikacjach, model nadaje się do wykorzystania we wszelkich typach przedsięwzięć, zarówno w sektorze wydobywczych jak i innych sektorach.

Słowa kluczowe: ryzyko, zarządzanie ryzykiem, model

1. Introduction

When talking about future events, besides uncertainty, the risk is the most often mentioned one. Risk implies an unexpected or unforeseen event. Often, risk is defined as the probability that an undertaking or a project will suffer a failure and consequences arising out of such failure.

In order to increase the level of investment security, particular significance belongs to assessment and prediction of the possibility of the arising of changes that may have an adverse impact on the project.

These are changes that lead to the loss of invested capital or erosion of its value, which limit the increase of invested capital and cause other tangible or intangible property damage, and loss of these values are called investment risks. All the above ranks the estimation of uncertainty and investment risk among the most subtle of investment operations. Estimates of the probability of occurrence of a risk event require a thorough and patient professional interdisciplinary paper that has to be based on modern methods and techniques of research and forecasting. Investments into new projects are followed by a number of specific risks arising at different stages:

- stage of preparation, review and approval of investment and technical documentation;
- stage of investment decision making and selecting of the investment project financing;
- stage of obtaining the founder's rights – location rights, construction and use rights;
- selection of the alternatives of acquiring investment equipment and materials offered by the market;
- performing investment works, such as: preparation of major, additional, final, and control works;
- stage of integration of an investment project into an environment in which it is constructed and used.

In all phases of the investment project, the possibilities of achieving optimal or sub-optimal investment solutions are open. The optimal solutions maximize the benefits, but suboptimal ones cause multiple damages. By optimization of the activities in all project phases the investors protect themselves from a number of risks and adverse consequences.

2. Types of investment risks

Investment risks can be analyzed from several viewpoints and can be grouped according to similar features. According to the forms and causes of occurrence, the following investment risks can vary:

– natural,
– technological,

– technical,
– market,
– financial,
– monetary,
– fiscal and
– others.

The risks on a project are defined by three key factors:
– Risk event,
– The probability of a risk,
– Amount of investment.

Risk event is an occurrence, activity or event that can bring adverse impact onto the project and the adverse and unwanted consequences.

The probability of risk represents a probability of occurrence of risk events, while the *Amount of investment* represents the amount of loss that may arise if the event occurred and made harmful impact onto the project.

3. Definition of risk

The risk is defined differently in the literature. It is usually defined in the narrow and broad sense (Kromschröder & Lück, 1998). In business economy, the risk – in the strict sense, according to the traditional view, represents the danger of suffering loss or damage. In a broader sense, risk describes the possibility of a different outcome than what was expected, either better or worse. Laws in Germany and Austria, define the risk as the danger that within a business activity losses can be incurred. ISO 31000:2009 defines risk as the effect of uncertainty on business objectives (ISO 31000, 2009). Although there are many different definitions, risk is commonly defined as the possibility of not achieving defined project objectives (Heldman, 2005).

4. Risk standards

In order to standardize the approach to building a risk management system and the risk management process, international norms were created. Their purpose was to standardize the conduct on a global scale. The result of such action are numerous risk management standards, two of which should be noted; AS/NZ 4360:2004 and ISO 31000:2009.

Standard AS / NZS 4360 is mentioned primarily because it preceded the ISO 31000 standard, which inherited numerous solutions with regards to the methodology and process orientation in the management system. AS / NZS 4360 was adopted and implemented in 1999, in thousands of organizations in Australia and New Zealand and around the world. It was established to enable a practical approach to risk management and its broad application.

International Standard ISO 31000:2009, as well as all other ISO standards, is of a global character. In 2010 it underwent through its application as the first international standard for risk management in the world.

5. Risk management methods

The methods used for the identification, assessment and evaluation of the reliability of the risk management process are numerous. According to their characteristics, they can be divided into the following groups (Risikomanagement für Organisationen und Systeme 2008):

- Methods of creative techniques (Brainstorming, Delphi technique and Morphology).
- Scenario analysis methods (Loss Analysis, Fault Tree, Workflow Analysis and Scenario Analysis).
- Methods of indicator analysis (Reporting on Critical Events, Risk Management on the basis of changes).
- Function Analysis Methods
- Statistical methods (Standard Deviation, Reliability Interval and Monte Carlo Simulation).

6. Concept of risk management

Causes and consequences of certain types of investment risks are different and therefore require different methods to assess the probabilities of their arising and various protective actions. A valid protection of investment risk, in the first place, requires the risks to be identified prior to making any investment decisions.

Likewise, it is necessary to provide information regarding the probability of occurrence of adverse events and to ensure protective actions against risks that can be expected. In doing so, it is crucial that the risks are realistically understood by both the investor and by the other participants in the investment process.

Although there are many different definitions, the risk is commonly defined as the probability of not achieving the defined goals of the project (Kerzner, 2003). It should be noted that not all risks are negative ones. In the same manner a risk can present a threat, it can also present an opportunity for the project. Each risk is related to a specific cause, and the realization of the risk event entails certain consequences that present a result of the realization of such risk event. The consequences can affect one or more project objectives and the project team must determine whether these effects have positive or negative impact. The risk in each case represents the uncertainty. The more is known about the risk and its impact onto the project, there is a higher probability that the risk shall be successfully managed with.

Regarding the project management, understanding the risks and knowledge of how to minimize its negative impact onto the project or how to fully utilize the chances are the key activities for the success of the project.

There are six key processes that make up the functional area of risk management, five of which belong to the planning group process. Risk management processes of the project are as follows (Project Management Institute, 2004):

Risk management planning involves the definition of the approach to be used in the risk management process. The main output element of this process is the risk management plan of the project.

Risk identification represents the definition of the various risk events that could affect the success of the project and registering their characteristics. A key result of this process is the risk register.

Quantitative risk analysis includes valuable impact assessment that identified and ranked risks may have on the project objectives. A key output of this process is to update the risk register.

Qualitative risk analysis involves the definition of priority of risk events based on the probability of their occurrence and prospective consequences. After identification, project teams may use various techniques for ranking the risks and for information update in the risk register.

Planning of risk response includes undertaking various steps in order to take advantage of chances or eliminate threats to the achievement of project goals. Using the results of previous risk management processes, the project team can develop strategies that result in updating the risk register and project management plan.

Risk monitoring and control involves monitoring of identified and residual risks, identifying new risks, carrying out risk response plans, and assessment of effectiveness of risk response strategies.

Figure 1 shows the risk analysis process model and risk management process model. Risk analysis phase model is comprised of three activities: risk identification, assessment and evaluation.

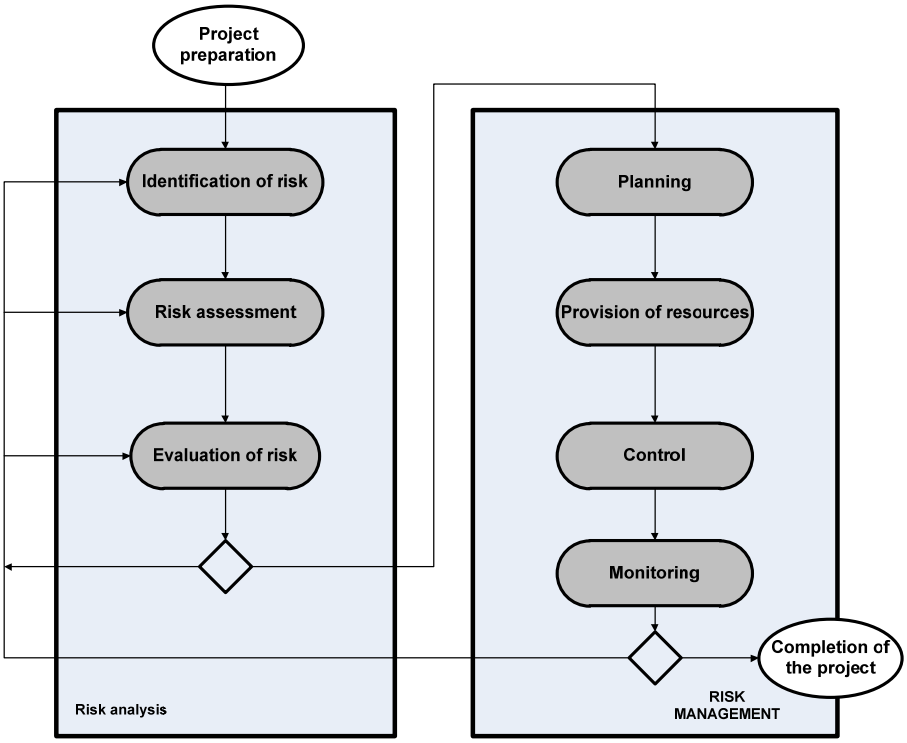

Fig. 1. Risk analysis process model and risk management process model (*Source:* Author)

Risk analysis results are used as a basis for risk management. The key results of the process include the recommended corrective and preventive actions, the required changes, update of the risk register, project management plan and organizational resources.

7. Risk management planning

The basic objective of this process is to define the Risk Management Plan, which represents a basis for understanding the remainder of the risk management process and the key result of risk planning process. In the process of risk planning it is necessary to take into account other project management processes, in order to ensure that the risk management plan is in accordance with the rest of the project.

This plan should provide a method of defining, monitoring and control of risky activities throughout the entire project, to precisely define the method in which the risk management processes will be implemented, monitored and controlled throughout the project lifecycle.

Categorization of risk is a systematic method of identifying a risk that should provide the basis for its understanding. Use of categories helps to enhance the identification process, by providing a standardized basis for describing the risk.

The following list includes some of the risk categories that can be identified in this process (Heldman, 2005):

- *Technical, qualitative and performance risks* – risks that are associated both with unreliable and complex technologies, and with changes in technology during the project realization.
- *Project management risks* – include inadequate planning of time and resources, the project as a whole, as well as the use of methods and techniques of project management.
- *Organizational risks* – may refer to conflicts between the resources due to the simultaneous implementation of several projects in the organization, unrealistic scope, time and objectives of the project in relation to available resources and organizational structure, lack of financial resources or transfer of funds to another project.
- *External risks* – are risks outside the project boundaries.

In the process of preparing a risk management plan, it is necessary to document the method of determining the probability of risk events occurrence and their impact onto project objectives. The probability represents a possibility i.e. the level of occurrence of a risk event, and an impact represents prospective consequences for the project in the event that a particular risk event occurs (Avlijaš, 2009).

The probability – impact matrix represents a combination of probability and impact values, which is intended to highlight those risks for which there is a need to develop a detailed response plan. If the matrix is not pre-defined by the organization, its preparation is essential during the planning and risk analysis. Thus defined, the matrix is used in the qualitative risk analysis.

It is crucial to identify and analyze the risks in the planning phase of the project, in order to be as ready as possible to response to them during the realization of the project. Therefore, it is necessary to:

- identify potential risks,
- analyze and evaluate the risks according to the importance,
- propose actions to eliminate or reduce the risks.

8. Identifying potential risks

The process of risk identification involves identifying and documenting all risks that may affect the project. In addition to the documentation it is required to register and document its characteristics that are considered important for the project. Risk identification is an iterative process that is constantly upgraded. As the project progresses through the stages of the lifecycle, so the new risks are perceived that are not identified during the planning process. After a risk is identified, it is followed by its analysis in order to prepare a response plan if there was a need for such action.

9. Risk management development model for the surface coal mine opening project

Risk management is an integral part of the management of each project, including the surface coal mine opening project. Project of surface coal mine opening is a very complex technical undertaking, whose implementation is followed by numerous risks.

Quantitative and qualitative impact of risk on the project itself, generally speaking, is largely dictated by the project environment, and then by the very activities that must be implemented within the project. The following tables provide an example of model risk management in surface coal mine opening project, which was created by combining the acquired knowledge from the available scientific literature and the authors experiences in previous work.

Figure 2 shows the implementation Risk management model on the surface coal mine opening project.

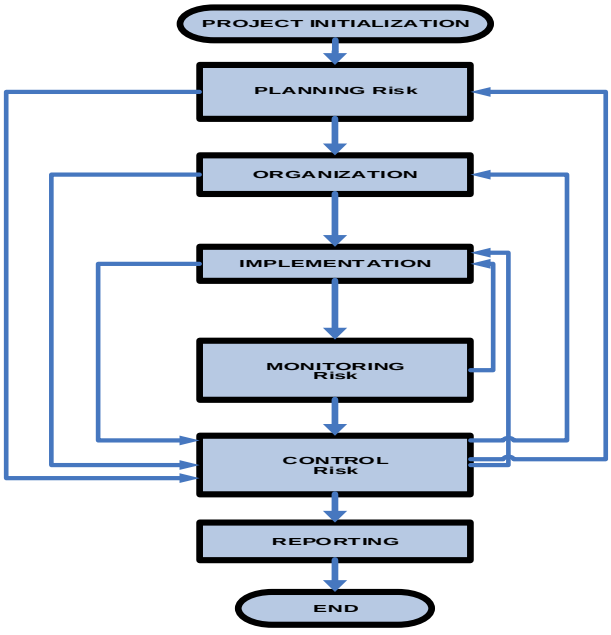

Fig. 2. Risk management model on the surface coal mine opening project

As a first step, it is necessary to perform the identification of potential risks and areas to which they relate. For having the best insight, the most appropriate manner is to display them in tables, particularly in Table 1. For the development of this model, nineteen group of risk events that have been adopted as a potential risk group, have been indentified. Some risks can be clearly qualified in a certain area although the rule for the majority of the risk policies is that their occurrence may have implications on a range of activities so that it is impossible to make a clear qualification. Of course, this list could not cover all the potential risks, because they primarily depend on the specific conditions under which the project is implemented.

In each case, the list of risk events can be updated in time, depending on the problems that are deemed as possible generators of potential risks.

TABLE 1

List of potential risks on the surface coal mine opening project

Potential risks	**The areas to which the potential risks relate**
The difference in interpretation of the results of research activities and the actual state	Conditions of working environment
Inadequate assessment of workload Modification of technical solutions	Scope
Inadequate assessment of the duration of the activity Inadequate schedule of activities Delay in delivery of the contracted equipment Technical and technological inability of performing certain work	Time
Inadequate assessment of project costs Currency conversion gain/loss Market change of prices	Costs
Inadequate assessment of required resources Incompetence and incompleteness of the project team Conflicts within the project team Inability to secure the necessary fundings	Resources
Inadequate organizational structure of the project Inadequate coordination of activities Incomplete and late communication	Organization of work
Changes in market conditions Change of legislation	External Factors

Source: Author

10. Quantitative risk analysis

Quantitative analysis includes four techniques: a sensitivity analysis, an analysis of the expected monetary value, decision tree analysis and modelling and simulation.

Sensitivity analysis is a quantitative method that analyzes the potential impact of risk events on the project. All elements of the uncertainty of events are examined first, followed by determining those that have the greatest prospective impact on project objectives.

Analysis of the expected monetary value (EMV) is a statistical method that calculates the average, or expected impact of different outcomes of risk events may have on the project. Posi-

tive outcomes of risk events essentially represent prospective opportunities for the project while the negative represent the threats.

EMV is calculated by multiplying the probability of risk event occurrence by the impact, followed by their adding together. EMV analysis is used together with the decision tree method.

Decision trees are diagrams that show the connection of interdependent decisions and the expected result of selecting one alternative over another. The method is based on the fact that usually there is more than one option when there is a need to make a certain decision, that is, more than one outcome when it comes to the risk event.

Modelling and simulations are widely used for the analysis of risks associated with the time and costs. Modelling allows the potential risks in certain moments of realization to translate into impacts and observe the consequences of the project objectives. Calculations on a project model are carried out by simulations, using a variety of inputs such as costs, duration of activities, in order to determine the probability distribution that a particular input belongs to. As an input variable for the cost WBS – Work Breakdown Structure or CBS – Cost Breakdown Structure are commonly used, while for the time period the preferred method is the method of network planning. The only output of the quantitative risk process analysis is an updated risk register.

11. Qualitative risk analysis

Process of qualitative analysis determines the impact that identified risks may have on the project goals and the probability that the risk events will come true. In addition, by qualitative analysis the risks are ranked according to their impact on project objectives. Ranking is done to determine whether it is necessary to do the quantitative risk analysis as well, and whether it is possible to skip making plans to risk response. This analysis takes into account the level of risk tolerance in relation to the project constraints (scope, time and quality) and a timeline of potential risk events.

The process of qualitative risk analysis has four input elements: organizational resources, a report on the scope of the project, risk management plan and risk register.

As with the process of identifying potential risks, it is necessary to analyze the historical information from previous similar projects that can be used as a guide for ranking of risks and setting of priorities. The report on the scope of the project, among other things, describes the project outputs and can be used as a help in determining the level of uncertainty and the scope of the current project compared to previous projects.

Methods and techniques used in the process of qualitative risk analysis are primarily focused on determining the probability of risk events and consequences that they may cause. The result of the process represents the updated risk register in which are documented all risks whose priority is determined by the methods of qualitative analysis. Methods and techniques used in this process allow the risk assessment, based on which the probabilities and impacts will be categorized.

The process of qualitative risk analysis usually involves the use of the following methods: assessment of the probability and impact of risk events, the probability – impact matrix, assessment of the risk data quality and categorization of risk and emergency risks assessment.

Assessment of the probability and impact of risks is a method which estimates the probability of achieving the identified risk events and determines the consequences that they may cause to the project objectives (time, scope, quality and costs). Such risk analysis identifies those risks that require most attention in the management process.

Probability indicates the uncertain events, and can, depending on the context, represent a chance, possibility or prospect that a particular event takes place. The sum of the probabilities that a particular event will be realized and the probability that the same event will not be realized is always 1. The probability is expressed on a scale from 0 (which means that an event will definitely not be achieved) to 1 (which means that a particular event will certainly be achieved (Mantel et al., 2008).

Determining the probability of risk can be very difficult, because it is mainly assessed by experts, who usually base their assessment on the experiences gained by working on similar projects. This results from the fact that each project is unique in its own way. Therefore it is necessary to develop appropriate criteria for determining the probability and include as many experts and different opinions as possible.

The impact of risk event represents the amount of damage (or benefit) that the realization of this event may cause to the project.

Scale of impact assessment can be a relative scale by which are assigned the values such as high-medium-low or a numerical scale, known as the cardinal scale. Cardinal scale values are numerical values that are assigned to risk events and range from 0 to 1, and for a scale display linear and non-linear increments can be used.

The table 2. shows the common scale of influence with respect to the time, cost and quality goals of the project. In the example, a relative scale was used, from the high-high value to the low-low value, but also, every relative scale value is associated with the corresponding cardinal value.

TABLE 2

The impact risk scale

Objectives	**Low-Low**	**Low**	**Medium**	**High**	**High-High**
	0.05	**0.20**	**0.40**	**0.60**	**0.80**
Costs	Insignificant impact	Increase less than 6%	Increase of 7-12%	Increase 13-18%	Increase more than 18%
Time	Insignificant impact	Increase less than 6%	Increase of 7-12%	Increase 13-18%	Increase more than 18%
Quality	Insignificant impact	Impact on couple of components	Significant impact	Unacceptable quality	Useless product

Source: Heldman et al., 2005

In the process of qualitative risk analysis, the probabilities and impact for each identified risk are determined. The next step in the qualitative risk assessment represents a matrix of risk that combines the values of the probabilities and impacts.

12. Analysis and assessment of risk

The risks represented in this manner have a quantitative character but for the purpose of their valorisation it is necessary to perform their qualitative assessment, and determine their impact onto the project. In this regard, it is necessary to determine two factors:

– Probability of a risk event occurrence, $F1$ and
– The impact of risk events on the project results , $F2$

Total factor F represents the product of two factors, $F1$ and $F2$, respectively:

$$F = F1 \times F2$$

TABLE 3

Probability of occurrence of a risk event, factor $F1$

Probability of risk event	Description	$F1$ value
Negligible	Not expected	1
Low	Can be expected very rarely	2
Medium	It is realistic to expect occurrence	3
High	Realistic probability of occurrence	4
Critical	It is expected almost certain occurrence, process or procedure is unreliable	5

TABLE 4

The impact of a risk event onto the project results, *F2* factor

Probability of risk event	Description	$F2$ value
Negligible	Does not affect the implementation of the project	1
Low	Does not affect the project to a great extent	2
Medium	Affects the future activities of the project; may, but does not have to jeopardize the project implementation	3
High	It conditions the modification of the project and threatens its very implementation	4
Critical	Impact to safety, leading to disruption of positive regulations and errors, causing great damage	5

TABLE 5

Risk classification according to the value of the final risk factors

The value of the final factor (F)	Class of risk
F = [1..5]	Minor risk
F = [6..10]	Significant risk
F = [11..25]	Critical risk

TABLE 6

Analysis and Risk Assessment on the surface coal mine opening project

List of potential risk event groups					Value of risk factors			Risk assessment
No.	Name of risk group	Impact on project			$F1$	$F2$	F	
		Scope of work(quality)	Time	Costs	Occurrence probability	Impact on project	Total factor	
1.	The difference in interpretation of the results of research activities and the actual state	x	x	x	2	4	8	significant
2.	Inadequate assessment of workload	x	x	x	2	3	6	significant

3.	Modification of technical solutions		x	x	2	2	6	minor
4.	Inadequate assessment of the duration of the activity		x	x	2	4	8	significant
5.	Inadequate schedule of activities		x	x	2	3	6	significant
6.	Delays in the delivery of the contracted equipment	x	x	x	2	4	8	significant
7.	Technical and technological impossibility of individual works	x	x	x	2	4	8	significant
8.	Inadequate assessment of the project cost	x		x	2	4	8	significant
9.	*Currency conversion gain/loss*			x	2	2	4	minor
10.	Change in the market price			x	2	3	6	significant
11.	Inadequate assessment of required resources		x	x	2	3	6	significant
12.	Incompetence and incompleteness of the project team	x	x	x	2	3	6	significant
13.	Conflicts within the project team		x	x	2	2	4	minor
14.	The inability to secure the necessary funding		x	x	3	4	12	critical
15.	Inadequate organizational structure of the project		x	x	2	4	8	significant
16.	Inadequate coordination of activities	x	x	x	2	3	6	significant
17.	Incomplete and late communication	x	x	x	2	3	6	significant
18.	Change of market conditions				2	2	4	minor
19.	Change of legislation		x	x	2	3	6	significant

Source: Author

As from the above table can be seen, only one (inability to secure the necessary funding) of the above 19 possible risk events can be marked as critical, 14 risk events are assessed as significant risk while 4 risk events are assessed as minor.

The risk assessment can be represented as in Figure 1, by qualitative analysis of potential risks in the surface coal mine opening project, according to the below specified method and obtained results.

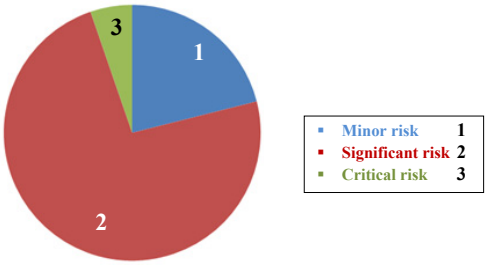

Fig. 3. Outline of risk structure on the surface coal mine opening project (*Source:Author)*

The above figure clearly shows that the surface coal mine opening project is primarily exposed to a number of significant risks, then to minor risks after implementation of the project, and only one of the total risks is categorised a critical risk.

13. Risk response planning

Risk Response Planning is a process of actions to be taken in order to eliminate the threats and exploit opportunities revealed in the process of risk analysis. This includes the allocation of responsibility for the execution of response plans, different sectors and employees in the organization. People who will be responsible for risk are called risk bearers. Response plans are made for those risk events that have a high probability of occurring and a significant impact on the project.

Response plan to risk events for which there is no high probability of occurrence and whose consequences are not significant, would be an inefficient waste of time of the project team.

The essence of the process of response plan is to spend fewer resources (time, money, and energy), then what would be spent if a particular risk event would be achieved, namely if the costs of response plan exceed the costs of the negative consequences of risk events, there is no point to plan a response.

Response plan is the process of formulating a strategy for risk management, i.e. finding and defining of management actions in the project by which the potential losses of risk events could be reduced to a minimum.

In order to manage risk effectively, it is essential that risk management team select the appropriate strategy for each risk (Jovanović, 2008).

After selection of the appropriate strategy, the action plan should be developed in order to implement the strategy in the event that the risk event occurs.

It is also possible to prepare a backup plan, or a second plan (Mallak et al., 1997). In practice, there are four techniques to risk (threat) response planning, each of which involves certain strategies, such as: strategy for negative risks (threats), strategy for positive risks (opportunities), strategy for positive and negative risks and contingency strategy.

14. Risk treatment plan on the project of opening the surface coal mine

In order to control the impact of risk events it is necessary to foresee a number of measures by which can be controlled, to some extent, the impact of certain risk events on the project itself. A series of actions by which it can fully or partly control the impact of risk events on the surface coal mine opening project is shown in Table 6. The provided set of actions is made by a combination of several strategies aimed to avoid or reduce impacts, and they are based on the following principles:

- Risk avoidance,
- Transfer of risk,
- Dealing with risk,
- Reduction of risk occurrence,
- Weakening of risk consequence,
- Planning of contingencies.

This table actually represents an action plan that can be implemented as a preventive action, as well as if it comes to implementation of a risk event with the aim to mitigate such risk event onto the course of the project.

TABLE 7

Risk Treatment Plan in Surface coal mine opening project

No.	Name of risk -Risk assessment-	Preventive actions to eliminate or reduce the risks	Possible consequences and actions in the event of risk	Expected outcome of treatment
1.	The difference in interpretation of the results of research activities and the actual state	– Detailed geological surveys and qualitative analysis of the results of these studies	– Increasing of work scope – Reducing the amount of mineral deposits, – Additional researches	– Increase of reliable information- – Reduction of workload
2.	Inadequate assessment of workload	– Establishment of an effective planning system – Creating a WBS	– Delay in realisation of the project – Cost increase – WBS corrections. – Term plan – Hiring of additional personnel	– Cancellation of time delays in future phases of the project
3.	Modification of technical solutions	– Detailed planning and creation of quality project solutions – Continuous monitoring of the latest technological developments	– Changes in volume – Increase in cost – Timely intervention at key points of the project	– Elimination of effects of risk with increasing of costs – Cancellation of time delays in the next phases of project
4.	Inadequate assessment of the duration of the activity	– Establishment of an effective system of planning and control at the level of project phases and its activities – Creation of WBS	– Delay in project implementation – Increase in cost – WBS restructuration	– Cancellation of time delays in future phases of the project
5.	Inadequate schedule of activities	– Establishment of an effective system of planning, following and control	– Delay in project implementation – Increase in cost – WBS restructuration	– Cancellation of time delays in future phases of the project
6.	Delays in the delivery of the contracted equipment	– Complete and timely contracting – Providing a guarantee for good execution of work	– Delay in project implementation – Increasing of costs – Activation of guarantee	– Delivery as soon as possible – Payment penalty
7.	Technical and technological inability of performing certain works	– Detailed understanding of all aspects of both the development of project documentation and the selection of a contractor	– Delay in project implementation – Increase of scope – Increase in cost – Quality impact – Hiring of specialists	– Cancellation of time delays in future phases of the project
8.	Inadequate assessment of the project cost	– Establishment of an effective system of planning and control at the level of project phases and its activities – Creation of CBS	– Increase in total cost CBS correction	– Ensuring of additional funding

9.	Currency conversion gain/loss	– CBS planning – Up to date following of the exchange list during the realisation	– Increase in cost – Link with stable currency	– Without significant influence on the course of the project
10.	Change in market conditions	– Detailed analysis of market conditions – Continuous monitoring and control	– Increase in cost – Delay of delivery – Intervention in areas that may be affected	– Implementation of the project according to the final term planned
11.	Inadequate assessment of required resources	– Planning – Controlling – Supplementing	– Delay in project implementation – Providing of the necessary resources	– Providing additional resources
12.	Incompetence and incompleteness of the project team	– Detailed analysis of human resources – Providing quality staff – OBS creation	– Delay in project implementation – Increase in cost – OBS correction	– Providing the necessary human resources
13.	Conflict within the project team	– Selection of a well comprised project team – Providing quality conditions for the work of the project team – Support from top management	– Violation positive and creative work discipline – The introduction of an effective system of incentives and sanctions	– Providing a positive and creative work discipline
14.	The inability to secure the necessary financial resources	– Providing more comprehensive knowledge of the characteristics of the financial environment, the movement of capital in the market and money supply and demand, the creditworthiness of banks and other financial institutions	– Delay in project implementation – Increase in cost – Correction of the financial structure	– Selection of optimal combination of financing in a given financial conditions
15.	Inadequate organizational structure on the project	-Selection of the optimal organizational structure – OBS creation	– Delay in project implementation – Increasing of costs – OBS changes	– Selection of optimal organizational structure
16.	Inadequate coordination of activities	– Providing constant communication between team members – Providing quality logistical support at all levels.	– Delay in project implementation – Increase in cost – Interventions by the project manager	– Establishment of an effective system of planning and coordination of project phases and its activities
17.	Incomplete and late communication	-Establishment of an effective system of planning and communication	– Delay in project implementation – Increase in cost – Interventions by the project manager	– Implementation of the project according to the final term planned

18.	Change of market conditions	– Detailed understanding of market conditions – Prediction of market conditions changes and response to possible changes	– Delay in project implementation – Increasing of costs	– Without significant influence on the final realisation of the project
19.	Change of legislation	– Detailed understanding of the legal and institutional framework – Monitoring of laws and regulations	– Delay in project implementation – Increase in cost – Timely preparation of necessary permits and approvals, as well as new requirements	– Without significant influence on the final realisation of the project

Source: Author

15. Conclusion

Great uncertainties and investment risks come from the environment itself in which investment projects are realized, such as: natural, technological, market, financial and many other risks that occur in the environment. From this it clearly follows that in the process of investment preparation, special attention must be paid to the prediction of the investment risk and taking adequate actions to protect against risk events. Underestimation or overestimation of any kind of investment risk, generates numerous negative consequences and devalues the very quality of investment.

By establishing an effective system of planning, monitoring and controlling of risk events, and by creating a risk treatment plan, the negative consequences of risk events in some stages of the project can be reduced or completely eliminated, in other words, their impact can be reduced onto the final implementation of the project in relation to the planned scope, quality, time and cost.

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