UDC 330.131.7:330.4
DOI: 10.15587/1729-4061.2024.313050

DEVISING A PROJECT RISK MANAGEMENT METHOD UNDER SCRUM CONDITIONS BASED ON COGNITIVE APPROACH

Tetiana Prokopenko
Corresponding author
Doctor of Technical Sciences, Professor*
E-mail: t.prokopenko@chdtu.edu.ua
Oleg Grygor
Doctor of Political Sciences, Professor**
Valentyn Prokopenko
PhD Student*
Olha Lavdanska
PhD, Associate Professor*
*Department of Information Technology Design***
Department of Economics and Management*
***Cherkasy State Technological University
Shevchenka blvd., 460, Cherkassy, Ukraine, 18006

Any project implemented using Scrum is characterized by the impact of risks, including negative changes in the environment and crisis circumstances. Therefore, the processes related to risk management, which is the object of this paper, become important. The problem solved in this study is to improve the efficiency of projects through the construction of a long-term strategy for reducing the level of risk and avoiding negative consequences for projects in the context of Scrum. The proposed method of risk management has been developed on the basis of the application of the synthesis of management of intelligent decision-making technologies and formalized methods. Difficult external circumstances are characterized by a high degree of uncertainty and do not always contribute to the successful implementation of the project. Therefore, this method of project risk management under Scrum conditions based on a cognitive approach is characterized by a combined combination of cognitive analysis, mathematical modeling, and expert methods. As part of the method, a model of project risk management under Scrum conditions has been built in the form of a fuzzy cognitive map, which could ensure determining the optimal strategic decision in dynamics, taking into account the effects of various factors. The result of applying this method is compliance with time limits, reduction of overspending of resources and losses in the project, as well as adaptation to rapidly changing circumstances and adequate response.

The method of project risk management is characterized by solving the problem of formalizing management decision-making procedures and their information support, taking into account the availability of both quantitative and qualitative data. Within the framework of this method, a project risk management procedure under Scrum conditions has been proposed, which contributes to the systematization, monitoring, and control of risks under the conditions of complex, rapidly changing crisis circumstances

Keywords: project, risks, Scrum, fuzzy cognitive map, factor, decision-making, information

Received date 09.07.2024
Accepted date 25.09.2024
Published date 30.10.2024

***How to Cite:** Prokopenko, T., Grygor, O., Prokopenko, V., Lavdanska, O. (2024). Devising a project risk management method under scrum conditions based on cognitive approach. Eastern-European Journal of Enterprise Technologies, 5 (3 (131)), 18–26. https://doi.org/10.15587/1729-4061.2024.313050*

1. Introduction

Decision-making processes in projects implemented in the field of information technology (IT) in the context of Scrum form the basis of management activities. They involve taking into account complex factors and influences of the external environment, and also ensure proper functioning and interaction. Optimal management solutions make it possible to achieve the goal with minimal expenditure of labor, material, and energy resources.

Project risk management in the context of Scrum, driven by both external events and internal situations, is characterized by a sharp change in circumstances. An important problem solved in this case is the development of a method based on the construction and analysis of visual formal models of the configuration of all factors forming a risk situation. The development of a risk management method for projects under Scrum conditions makes it possible to determine the dynamics of achieving goals, implementing tasks, and changing project performance indicators under different external and internal conditions. In other words, to predict options for the development of risk in the project (within the configuration) and thereby reduce the "uncertainty of the future".

Project risk management under Scrum conditions based on the modeling of the dynamics of risk configurations in the project will ensure the determination of effective strategic and operational decisions as a result of awareness of future changes in the external environment. At the same time, the dynamics of the project's development are traced, taking into account the risk, new opportunities are developed for the further development of the project; preparations are made for possible changes in the business environment to reduce the negative consequences of adverse situations and reduce the risks of capital investments.

The development of a project risk management method under Scrum conditions based on a combined combination of various methods and approaches will contribute to the search for the most rational options for project and management solutions. This will ensure in practice building a long-term strategy for reducing the level of risk and avoiding negative consequences for projects in the Scrum environment based on the application of the synthesis of the management of intelligent decision-making technologies and formalized regular methods. Therefore, the study of project risk management in the context of Scrum and the development of relevant information technologies are relevant.

2. Literature review and problem statement

Under modern conditions, significant attention is paid to the issue of risk research in projects of various industries, their evaluation, analysis, development of various risk avoidance measures or their minimization. The research results [1] show that risk management processes are an important component in achieving efficiency and effectiveness. However, the cited study focuses on the importance of risk control in order to achieve profit. In [2], the principles and concept of risk management, features of risk management in projects, risk management processes, etc. are described, representing the format of instructions and risk management algorithm for project managers. However, various factors of the external and internal environment of the project, which determine the effectiveness of the implementation of management decisions, are not considered. Work [3] shows that one of the most important stages of decision-making in the project is risk management, which includes risk monitoring. But the issues of the process of systematic control and evaluation of the effectiveness of actions aimed at preventing and minimizing the consequences of risks, as well as identifying new risks in accordance with the system of advantages adopted for this, remain unresolved.

Conventional approaches to solving the problems of risk management of projects in various industries are based on methods of identification and planning of response to risks, as well as on determining the quantitative assessment of risks. Similar studies are based on the PERT analysis method [4], which involves the analysis of tasks based on data on time and scope of work. However, the impact of various events and circumstances that can radically change the course of the project is not taken into account. Complex calculations of the Monte Carlo method [5] are based on the theory of probabilities and tables of random numbers and do not provide consideration of information of a qualitative nature. Methods of descriptive statistics [6] use empirical data and do not take into account the possibilities of probability theory. Correlation and regression analysis methods [7] are effective in cases of complete availability of statistical information. However, they do not take into account the possibility of rapid change under the influence of external and internal factors. Expert methods used in works [8, 9] also provide an opportunity to research information of a qualitative nature when it is impossible to apply precise formalized methods.

For projects, it is necessary not only to identify the current situation as risky but also to determine rational ways of achieving project goals under crisis conditions. In [10], the authors proposed a comprehensive method of situational project risk management based on the combined application of situational analysis methods, intellectual and expert methods, as well as Big Data technology. The complex method of situational project risk management is characterized by solving the problem of formalizing management decision-making procedures and their information support, taking into account the presence of both structured and unstructured data. Therefore, it is necessary to conduct research that will deepen this direction and take into account the peculiarities of projects in the field of information technologies implemented under the conditions of Scrum.

In [11], the authors propose the use of logistic regression to study the influence of factors that determine the probability of perceived risk, using information on the size, industry, and business situation of companies, together with data on their capital and status. Analyzing the current business situation, the authors provide stylized facts about risk perception. However, the work does not define how the factors affect each other and what negative consequences a combination of influences may have.

In [12], the authors use regression analysis of panel data as a research method. However, this method is based on obtaining accurate statistical data and does not take into account the availability of qualitative information.

The authors of paper [13] conduct a comprehensive study of risk management in practice beyond the formal, explicit risk management process, including informal and/or implicit risk management actions. An advantage of this empirical study of risk management is that informal and/or covert risk management actions dominate in practice. The paper provides a discussion of why risk management is carried out outside a formalized clear process, as well as a research program to enable the development of effective project risk management. However, the paper shows a study of cause-and-effect relationships of factors that lead to the occurrence of a risk event, which is a drawback.

Work [14] reports a study of project risk management related to Agile Artificial Intelligence and Machine Learning data and models. In the work, the authors propose the development of a system framework for effective risk control using flexible methodologies. The research is based on an interpretive approach and uses a deductive method that creates a framework for identifying and mitigating risks. The advantage of the work is a proposal to reduce the negative impact of risks in the project of dynamic allocation of resources, the stability of the model, the integration of risks and the assessment of the quality of information. However, the main measures in the study are aimed at risk directly, which may not have the desired effect. Therefore, the lack of research into the cause and circumstances causing the occurrence of a risk event can be considered a shortcoming of this work.

Paper [15] proposes the use of Bayesian networks in risk management of information technology projects. This provides an opportunity to study various risk scenarios by simultaneously taking into account various factors of the external environment and the internal state of the project, as well as determining the most likely among them. This research requires a more in-depth study of different risk event scenarios and response measures.

Our review of the literature [4–15] revealed that the existing models and methods of project risk management in various fields do not provide opportunities for researching the cause-and-effect relationship between risk-generating factors and risk events, as well as risk control measures. There are also no models and methods that would provide opportunities in the dynamics of representing information of various kinds and nature, including qualitative expert information, as well as take into account the peculiarity of projects in the context of Scrum. Therefore, to solve this task, it is necessary to apply a combined approach based on a complex combination of cognitive analysis and expert methods. This will provide an opportunity to support decision-making in risk management of information technology projects implemented under Scrum conditions, taking into account the effects of external and internal environmental factors, which is the basis of the development of the appropriate information technology.

3. The aim and objectives of the study

The purpose of our work is to devise a project risk management method in Scrum based on a cognitive approach characterized by a combined combination of cognitive analysis, mathematical modeling, and expert methods. This will ensure the possibility of making management decisions in dynamics with minimal influence of the human factor in difficult, crisis circumstances to increase the efficiency of projects under Scrum conditions.

To achieve the goal, it was necessary to solve the following tasks:

– to build and research a project risk management model under Scrum conditions in the form of a fuzzy cognitive map, which will ensure the determination of the optimal strategic decision in dynamics, taking into account the effects of various factors;

– to justify and investigate the project risk management procedure under Scrum conditions, which will contribute to the systematization, monitoring, and control of risks under the conditions of complex, rapidly changing crisis circumstances.

4. The study materials and methods

Innovative processes play an important role in the development of any industry, in particular the field of information technologies. Projects implemented by IT companies under modern conditions are based on the application of flexible management methodologies, including Scrum. Therefore, in the new concept of project management, the issue of risk management deserves special attention, which is the object of this study.

Decisions about radical changes in the project, caused by changes in the external environment and within the project, are currently called strategic decisions. The essence of the transition from operational management to strategic management is to shift the focus of project management to the complex external environment in order to respond appropriately and in time to the changes occurring in it. Therefore, the combined combination of a cognitive approach, mathematical modeling and the method of collective multivariate expertise will provide an opportunity for operational risk management in a strategic perspective for projects implemented under Scrum conditions. This is the main hypothesis of our study.

The main criterion for evaluating decisions made during project risk management under Scrum conditions is project effectiveness. Therefore, it is necessary to take into account the following assumptions adopted in the study:

– the negative consequences of mistakes in choosing a strategy and its implementation are sharply increasing, which affects the effectiveness of the project;

– routine, usual procedures and schemes do not work;

– increasing complexity and variability of development processes.

Risk management is relevant, taking into account the factors of instability of the external environment, the internal state, the strengthening of uncertainty factors and the acceleration of all business processes that require a quick response. With conventional logic, risks were considered as an inevitable calamity that should be foreseen or hidden. The project manager tries to deal with risks through detailed planning, regulation, and precise execution of the plan. With a new approach to project management, risks are openly recognized as part of the real world and considered as the most important part of management and planning.

One of the problems when trying to formally model the process of risk management is the study of causal relationships between the conditions and reasons for the occurrence of risk events and measures to reduce the level of risk, as well as the possibilities of avoiding risk. At the same time, the speed and adequacy of decision-making, as well as their implementation in the project, must correspond to the speed and depth of changes occurring in the realities of the surrounding environment.

The use of the cognitive approach, as one of the research methods, provides opportunities for formalized description and creation of risk management scenarios, while not absolutizing both formalized and informal procedures for finding effective solutions. Risk management is a weakly formalized subject area, so the cognitive approach [16] of research has a number of advantages. Among the main ones, it is worth highlighting the possibilities of generation and analysis of possible scenarios of the development of the situation over time, as well as the formation of possible alternatives for management decisions.

When analyzing and improving project risk management processes under Scrum conditions, non-standard problems that do not have ready-made solutions often arise. In such cases, it is necessary to rely on the opinions of specialists who have a lot of experience and are well acquainted with certain aspects of this problem, that is, experts, and to apply expert methods.

Usually, classical methods of examination, in which the opinions of experts are considered "objective", offer a set of ready-made options. At the same time, clear (quantitative or ranked) evaluation criteria are set, and the simplest statistical procedures are used to process expert evaluations. In this case, such methods are unacceptable. The application of expert methods in this study is to some extent accepted simplifications. However, in this case, taking into account the availability of qualitative information, it is appropriate to use expert methods. In particular, it is worth highlighting the method of collective multivariate examination, which is characterized by a comprehensive and reasoned assessment of expert opinions, indicating all advantages and disadvantages. In addition, the application of this expert method neutralizes the negative impact of the human factor, which is essential for projects that are implemented under the conditions of Scrum application. Considering the fact that the distribution of roles in the project according to Scrum can be different, and the experts are directly members of the project team, the influence of the human factor should be minimized in the process of making adequate management decisions. It is safe to say that today one of the main problems that arise when trying to formally model the human factor is the development of adequate decision-making models.

One of the components of the decision-making process under risky conditions is the ability to quickly adopt the measures necessary for the project in the event of a sudden and unexpected change in the situation. These changes can be of such a nature that it is impossible to resist purely operational influences during the implementation of the decisions made.

Decisions that radically change the project are necessary. To make such decisions, it is necessary that:

– the system of monitoring and analysis of project results timely warned the project management about emerging changes or unexpected sudden changes in the situation that may require drastic measures during the implementation of the project;

– project management was able to conduct a forecasted analysis in a timely manner, understand the nature of threats that may arise, and based on its results, generate possible countermeasures, evaluate them, rank them, choose the most effective ones, and implement them.

5. Research results related to project risk management method under Scrum conditions based on cognitive approach

5. 1. Cognitive model of project risk management under Scrum conditions

During the formalization of the risk management process for projects implemented under the conditions of Scrum application, it is necessary to obtain a solution to the problem, which takes into account and describes all the parameters that affect the future results of the effective implementation of the project. Therefore, a comprehensive study of risk and the process of risk management, taking into account both quantitative and qualitative data based on a cognitive approach, is appropriate. Building a cognitive model of risk management will make it possible to represent the risk situation in the form of a set of influences of external and internal factors with the determination of connections that lead to the occurrence of a risk event. At the same time, the main parameters of risk formation are not quantitative, but qualitative. At the same time, the representation of the risk situation is taken into account based on receiving verbal assessments of experts. However, a number of factors and relationships can be represented quantitatively as a result of statistical data processing since different factors can be estimated based on different sources. The data on which project risk management is carried out under Scrum conditions is qualitative, vague, and subjective, which is a reflection of the knowledge of experts. Therefore, the application of a cognitive approach will provide opportunities to take into account the loose structure and diversity of data in the process of modeling risk management.

Using the methodology from [17], a fuzzy cognitive map of project risk management under Scrum conditions was built based on the study of the effects of various factors that in a complex interaction lead to the occurrence of a risk event. To this end, it is necessary to conduct preliminary research, which is represented in the form of the following diagram (Fig. 1).

The formation of a system of factors and the relationships between them in the process of building a cognitive model of project risk management under Scrum conditions is based on the analysis of the current situation. The essence of this process is to distinguish and compare the effects of some factors on others through third ones. This will ensure the formation of possible alternative solutions in the process of risk management. Such alternatives are a set of management factors, i.e., factors that can be directly influenced by the project manager. In the process of further analysis when building a cognitive map of project risk management, it is important to select factors with a stronger influence on the target factor, that is, the factor. The value of it must be changed.

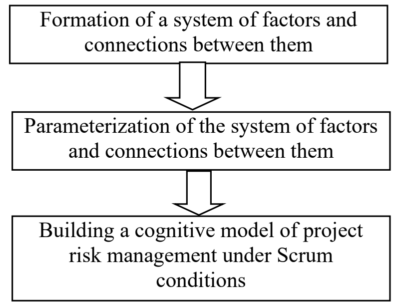

Fig. 1. Scheme of formalization of the project risk management process under Scrum conditions based on a cognitive approach

The risk management model of projects implemented under the conditions of Scrum application, based on the cognitive approach, represents a fuzzy cognitive map. Formally, the cognitive map of project risk management in the context of Scrum represents a directed graph with a set of vertices corresponding to factors and a set of edges that are connections between factors. Edges define cause-and-effect (causal) connections between factors characterizing their mutual influence on each other. Scales characterize the influence of factors. In this case, in order to characterize the strength of influence between nodes-concepts, weights w_{ij} are introduced, which characterize the degree of influence of one concept on another using the value of a linguistic scale of the type (very small, small, medium, large, very large). The values of weights w_{ij} are established by the expert method. The survey of experts was implemented using the Delphi method.

Relationships between factors are represented as direct and indirect effects. A feature of direct influence is the influence of adjacent vertices, i.e., factors. Direct influences are specified based on the elements of the adjacency matrix. In contrast to the direct effect, the indirect effect of factor i on factor j is determined on the basis of the total representation of the effects through the path, the length of which is greater than 1, going from factor i to factor j. That is, the total effect is the resulting effect according to all paths from factor i to factor j. In order to determine the value of the parameters of the peaks of the cognitive map and the degree of influence, the method of expert evaluations is used.

According to the Kosko model [18], the parameterization of impacts is implemented based on the calculation of indirect and total impacts. The indirect effect N_p of factor i on factor j through the path P passing from factor i to factor j is determined based on the following relationship [19]:

$$N_P = \min_{k,l \in E(P)} w_{kl}, \quad (1)$$

where $E(P)$ is the set of edges of the path P and w_{ij} is the weight of the edge (k, l) of the path P, which is expressed in terms of linguistic variables.

The total influence S_{ij} of factor i on factor j is calculated as follows:

$$S_{ij} = \max_{I_P} N_P, \quad (2)$$

where the maximum is determined based on all paths $P(i, j)$ from factor i to factor j. Thus, N_p is the weakest link of the P path, and S_{ij} is the strongest of the indirect effects of N_p.

To build a fuzzy cognitive map of project risk management under Scrum conditions, the following factors (concepts) were selected, including:

– *reason* – events in the external or (and) internal environment of the project that are the cause of the possible occurrence of a risk event;

– *trigger* – events in the external or (and) internal environment of the project that lead to the possible occurrence of a risk event;

– *risk* – risks caused by certain events in the external or (and) internal environment of the project;

– *indicator* – indicators of forecasting the emergence and development of risk;

– *problem* – an indicator of the consequence of risk for projects under Scrum conditions;

– *decision* – measures necessary to prevent or reduce the level of various risks;

– *efficiency* – indicators of project efficiency under Scrum conditions.

Analysis of the constructed fuzzy cognitive map of risk management of projects (Fig. 2), which are implemented under the conditions of Scrum application, reveals how various factors affect the occurrence of a risk event and the possibility of avoiding it. Let $E_{ij}^{(m)}$ and $I_{ij}^{(m)}$ be the number of positive (according to the decision) and negative (forced due to the occurrence of certain events) paths of length m going from factor i to factor j, respectively. Then the total positive and negative effects of factor i on factor j are determined as follows [20]:

– positive influence:

$$pz_{ij} = \sum_{m=1}^{\infty} f(m) E_{ij}^{m};$$

– negative influence:

$$nq_{ij} = \sum_{m=1}^{\infty} f(m) I_{ij}^{m},$$

where $f(m)$ is a monotonic non-decreasing function of the path length m, which determines the degree of attenuation of the influence on the path from i to j. A monotonically decreasing and differentiable function is chosen as $f(m)$:

$$f(m) = z^{m} \left(0 < z < 1\right),$$

where z is the coefficient that determines the degree of attenuation.

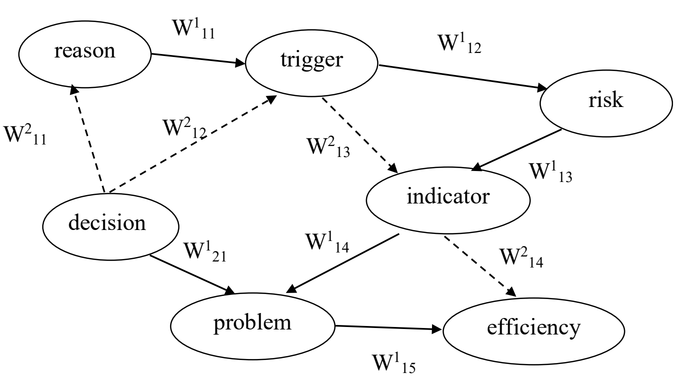

Fig. 2. Generalized fuzzy cognitive map of project risk management under Scrum conditions

Let j be a factor lying on the path between factors i and k. Then the positive *spik*(j) and negative *snik*(j) components of the influence of factor i on k through factor j are determined as follows:

$$pz_{ik(j)} = pz_{ij} pz_{jk} + nq_{ij} nq_{jk},$$
$$nq_{ik(j)} = pz_{ij} nq_{jk} + nq_{ij} pz_{jk}. \quad (3)$$

On the basis of these ratios, matrix operations are built, which allow effective calculation of causal effects. To this end, first of all, it is necessary to determine the positive and negative valence matrices $pz=[pz]_{ij}$ and $nq=[nq]_{ij}$ based on the original adjacency matrix $W=[w_{ij}]_{n\times n}$ of the cognitive map:

$$pz_{ij} = \begin{cases} +1, \text{ if } w_{ij} = +1, \\ 0 \text{ otherwise,} \end{cases}$$
$$nq_{ij} = \begin{cases} +1, \text{ if } w_{ij} = -1, \\ 0 \text{ otherwise.} \end{cases} \quad (4)$$

These matrices are used to calculate influences through paths of length m. Denote by $Pz^{(m)} = \left[pz_{ij}^{(m)} \right]$ and $Nq^{(m)} = \left[nq_{ij}^{(m)} \right]$ the matrix, the elements of which are positive and negative influences through paths of length m. Then:

$$Pz^{(m)} = Pz^{(m-1)} Pz^{(1)} + Nq^{(m-1)} Nq^{(1)},$$
$$Nq^{(m)} = Pz^{(m-1)} Nq^{(1)} + Nq^{(m-1)} Pz^{(1)}, \quad (5)$$

where

$$Pz^{(1)} = \left[pz_{ij}^{(1)} \right] = \left[f(1) p_{ij} \right] = hP,$$
$$Nq^{(1)} = \left[nq_{ij}^{(1)} \right] = \left[f(1) nq_{ij} \right] = hNq.$$

In addition:

$$Pz^{(m)} = 0.5\left\{ \left(Pz^{(1)} + Nq^{(1)}\right)^{m} + \left(Pq^{(1)} - Nq^{(1)}\right)^{m} \right\},$$
$$Nq^{(m)} = 0.5\left\{ \left(Pz^{(1)} + Nq^{(1)}\right)^{m} - \left(Pz^{(1)} - Nq^{(1)}\right)^{m} \right\}. \quad (6)$$

Let us denote the matrices of the total positive and negative influence, respectively, by $Pz = \left[pz_{ij} \right] = \sum_{l=1}^{\infty} Pz^{(l)}$ and $Nq = \left[nq_{ij} \right] = \sum_{l=1}^{\infty} Nq^{(l)}$, where pz_{ij} is the total positive influence from factor i to factor j through all paths of arbitrary length; similarly, nq_{ij} is the total negative impact. Then:

$$Pz = 0.5\begin{bmatrix} \left(Pz^{(1)} + Nq^{(1)}\right)\left\{I - \left(Pz^{(1)} + Nq^{(1)}\right)\right\}^{-1} + \\ +\left(Pz^{(1)} - Nq^{(1)}\right)\left\{I - \left(\tilde{P}z^{(1)} - Nq^{(1)}\right)\right\}^{-1} \end{bmatrix},$$
$$Nq = 0.5\begin{bmatrix} \left(Pz^{(1)} + Nq^{(1)}\right)\left\{I - \left(Pz^{(1)} + Nq^{(1)}\right)\right\}^{-1} + \\ +\left(Pz^{(1)} - Nq^{(1)}\right)\left\{I - (\left(Pz^{(1)} - Nq^{(1)}\right)\right\}^{-1} \end{bmatrix}, \quad (7)$$

where I is the unit matrix.

The choice of parameter h is based on the statement proved in [20], the essence of which is as follows:

– if all the eigenvalues of the matrix ($Pz^{(1)}+Nq^{(1)}$) do not exceed 1, then the values of the matrices Pz and Nq converge to the final values;

– if χ_{max} is the maximum eigenvalue of the matrix ($Pz+Nq$), then h must be in the range $0<h<1/\chi_{max}$, if $\chi_{max}>1$, and $0<h<1$, if $\chi_{max}\leq 1$, since ($Pz^{(1)}+Nq^{(1)}$) is equal to h ($Pz+Nq$);

– if the value of h is close to $h_{max}=1/\chi_{max}$, then the positive and negative influences between the factors become less noticeable.

Therefore, h should be chosen less than χ_{max}. As h decreases, the influence of long paths on the final result decreases; therefore, by changing h, it is possible to analyze the effect of paths of different lengths on the final result.

In order to represent the dynamics of changes in the project based on (1) and (2), the dependence on time t will look like this:

$$N_P(t)=\prod_{(i,j\in E(P)}\psi_i(t)\cdot w_{ij}, \qquad (8)$$

where $E(P)$ is the set of edges P, the state of the vertex i at time t, w_{ij} is the weight of the edge (i, j) of the path P. Accordingly, the total influence S_{ij} of factor i on factor j, taking into account all paths, is calculated as follows:

$$S_{ij}(t)=\sum \max N_P(t). \qquad (9)$$

Based on the values of w_{ij} obtained by the expert method and calculations according to (3) to (7), we shall obtain the following Np for each of the paths (the calculation was performed on the basis of conditional values on the example of an academic project in the field of information technologies) at different points of time corresponding to project milestones (Table 1).

As a result of calculations according to formula (8), we can obtain the results of S_{ij} values above 1. Limiting the range of S_{ij} values to the interval [–1; +1], we get the opportunity to interpret these values in a vague linguistic scale from very weak to very strong positive or negative influence. At the same time, we take into account that we have a poorly structured situation for an expert and a project manager to accurately quantify the impact. Based on (8) and the values in Table 1, we get the following total values of S_{ij} for each P: 0.523, 0.68, 0.932, 0.932, 1.31.

The obtained values make it possible to assess the influence of factors on each other and on the effectiveness of the project as a whole in order to determine the key factors that require increased attention. This will contribute to the possibility of a preventive response to changes that may negatively affect the results of the project. That is, the opportunity to respond through the risk indicator through the implementation of appropriate anti-risk measures has been obtained. In addition, the obtained values of the total influence of factors allow us to develop strategic decisions aimed at optimizing the project. In this way, it is possible to increase the impact of positive factors or reduce the negative impact, which will increase the overall effectiveness of the project.

5. 2. Project risk management procedure under Scrum conditions

The project risk management procedure under Scrum conditions will be demonstrated using the following generalized structure of risk monitoring and control (Fig. 3).

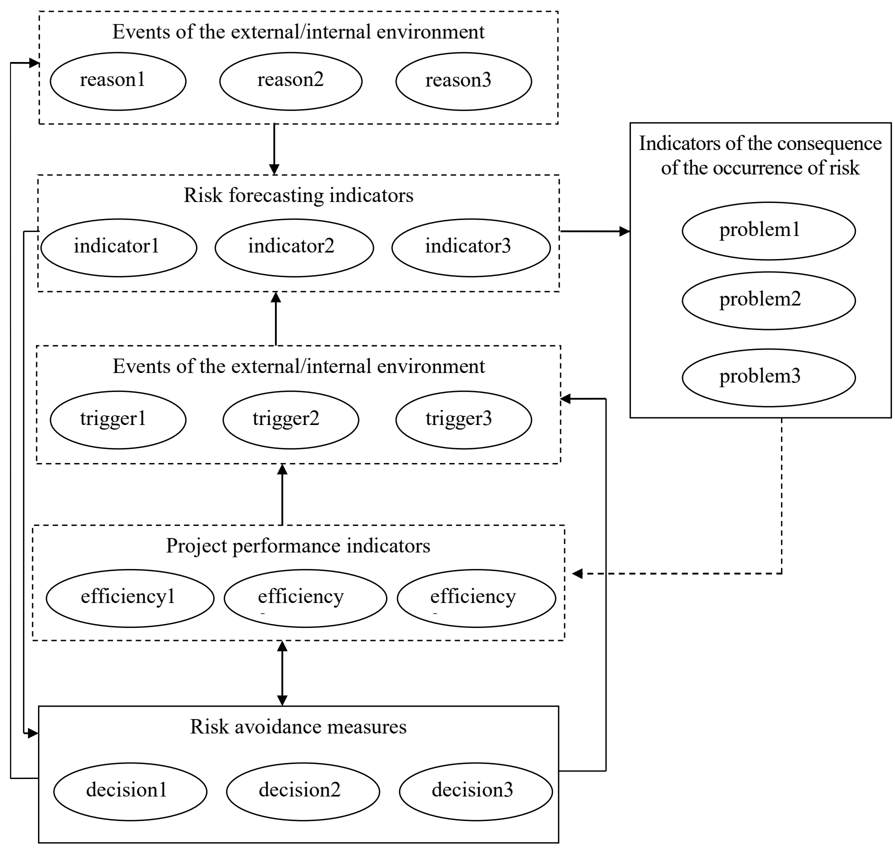

Fig. 3. Generalized structure of project risk monitoring and control under Scrum conditions

Table 1

Table of values of indirect effects at different points in time of the project

P	*Np*1	*Np*2	*Np*3	*Np*4	*Np*5
(reason, trigger, risk)	0.25	0.2 8	0.29	0.17	0.28
(reason, trigger, risk, indicator, problem)	0.24	0.176	0.21	0.18	0.2
(risk, indicator, problem, efficiency)	0.29	0.276	0.351	0.261	0.252
(decision, indicator, indicator, efficiency)	0.267	0.209	0.287	0. 257	0.245
(decision, problem, efficiency)	0.31	0.278	0.376	0.278	0.252

As the main elements of this structure, various factors influencing the effectiveness of the project are considered, according to the constructed generalized fuzzy cognitive map of project risk management under the conditions of Scrum.

Under the elements of the external environment (factors of the external environment), which are a source of risk for projects under Scrum conditions, we shall understand competitors, consumers, suppliers, market conditions, actions of local and central authorities, etc.

Under the elements of the internal environment (factors of the internal environment) unusual, critical, crisis situations can occur, leading to the loss of various types of resources. Risk indicators include indicators that show the presence and level of risk for the effective implementation of the project. Examples of risk indicators for projects under Scrum conditions are a decrease in market share, the degree of activity of competitors in the field of innovation, etc. Indicators that characterize the consequences of risk for projects under Scrum conditions are such performance indicators as a decrease in the level of competitiveness, a decrease in profitability, a decrease in the exchange rate of shares, losses from investment and innovation activities, etc.

Measures to prevent or reduce the level of risks of various types include risk avoidance measures; risk localization; risk dissipation (distribution) and risk compensation [21]. If the time factor is taken into account, these measures are included in the groups of preventive measures; measures implemented in the event of a risk; contingency plan measures. The latter are used in situations when the measures of the main plan do not have the necessary impact on the level of risk and the degree of its negative impact on the project.

For the constructed fuzzy cognitive maps, the degree of comprehensive (including indirect) impact of measures on risk forecasting indicators is determined. Next, those measures are chosen that, with the least costs, provide the greatest impact on the level of risk and its possible consequences. At the stage of monitoring risk situations, the probability of risk occurrence is assessed and calculated on the basis of research (1) to (9), which determines the compliance of the risk possibility with anti-risk measures. For each interval of risk values, which may, for example, correspond to admissible, acceptable, and unacceptable risk levels, effective primary and backup measures are selected that have the greatest impact on the probability of risk occurrence. During the implementation of the project, the values of all the concepts of the constructed fuzzy cognitive map change, which leads to a change in the values of the risk indicators. At the same time, obtaining data values in predetermined intervals determines the feasibility of implementing appropriate measures to reduce the level of risk or its possible negative consequences.

6. Discussion of results of research on the project risk management method under Scrum conditions based on a cognitive approach

The proposed risk management method is based on a project risk management model implemented under Scrum conditions, in the form of a fuzzy cognitive map (Fig. 2). This model is distinguished by the presence of nodes – concepts that reflect the sources of risk situations in the external and internal environment of the project, as well as nodes that reflect risk management measures, which is an advantage. In the course of a preliminary study of the problems of project risk management, we used graph-analytical models [10], Bayesian networks [15]. However, these modeling tools are too cumbersome. Therefore, in the case when it is necessary to represent the problem in the form of a dynamic structural model consisting of a set of heterogeneous objects, it is advisable to use fuzzy cognitive maps.

The specified approach to the construction of project risk management models under Scrum conditions is expedient to apply in the absence of statistical information, which is an advantage of this method. Also, this approach, in contrast to [2–10], is relevant in case of impossibility of representing risk characteristics using metric scales, which reduces efficiency or makes it impossible to use statistical methods of risk analysis. At the same time, the construction of a vague cognitive map and, if possible, the use of statistical risk assessment makes it possible to visually depict all the elements of the risk situation and the connections between them. This will contribute to the understanding of the internal and external processes of the project that affect risks of various types, and, accordingly, to increase the validity of risk management decisions.

The specificity of cognitive modeling is that formal mathematical methods of analysis are applied to models describing the subjective vision of the situation. At each stage of model formation, decisions have to be made, the totality of which ultimately determines the adequacy of the built model. Adequacy is finally determined only in the process of real work with the model. From this, in particular, it follows that information technologies for supporting decision-making, based on a cognitive approach, should be as open as possible to modifications. However, it should be noted that the very process of building the model turns out to be very useful for analysts of the problem even at the beginning of the calculations, because it forces to structure the problem area. With the formal allocation of factors and connections between them, previously neglected aspects of the situation, the connection that seemed insignificant, are inevitably revealed, and a system of concepts is formed, in the terms of which even an informal discussion of the problem becomes clearer and more justified, which distinguishes this study from [11–15].

The main advantage of the proposed project risk management model under Scrum conditions in the form of a fuzzy cognitive map is the possibility of systematic qualitative (that is, not quantitative) consideration of the remote consequences of the decisions made. The use of a cognitive approach helps identify side effects that can prevent the implementation of seemingly obvious solutions. In addition, this applies to decisions that are difficult to evaluate intuitively due to the large number of factors and the variety of numerous ways of interaction between them. At the same time, one should beware of inflated expectations when using this device, even if the built model is recognized as adequate. The results of analysis (1) to (9), which are usually formulated in terms of linguistic scales, are quite rough due to the roughness of the scales themselves. They are able to reflect the main trends of impacts, but can be unreliable, for example, with an approximate level of positive and negative impacts. However, the indicator of such unreliability is the small values of the calculated consonances, which is a drawback of this method.

Our study was based on a simple academic example of a project in the field of information technology under Scrum conditions, which provided an opportunity to visually represent the factors and the relationships between them, which is a limitation of this study.

The proposed method of risk management based on fuzzy cognitive maps, mathematical modeling, and expert methods, in contrast to [6–10], has a number of advantages. First of all, this method makes it possible to identify the sources of risk events in the external and internal environments of projects under Scrum conditions. In addition, it contributes to the assessment of the degree of influence of factors on project performance indicators, as well as the determination of risk avoidance measures. This method is used during the development of alternative solutions for achieving project goals, which allows for the selection of the most effective strategic project solution according to the risks taken into account. The result of the application of this method is an increase in the efficiency of projects due to the avoidance of overspending of resources and losses in the project by 5–15 %. This method promotes adaptation to the conditions of the external environment, as well as prompt and adequate response in crisis situations with minimization of the influence of the human factor.

The proposed project risk management method under Scrum conditions may become the basis of project management information technology and the corresponding decision support system. This will make it possible to expand the intellectual capabilities of supporting management decision-making in projects. This area of research and the development of appropriate software is the subject of further studies.

7. Conclusions

1. A model of project risk management under Scrum conditions has been built in the form of a fuzzy cognitive map, which would provide opportunities to optimize strategic decisions. This model clearly demonstrates the cause-and-effect relationships between the factors leading to a risk event, in the dynamics, and the possibility of avoiding risk, as well as determining the future strategy.

2. As part of the risk management method in the context of Scrum, the project risk management procedure has been substantiated and researched. This will contribute to the systematization, monitoring, and control of risks under the conditions of complex, rapidly changing crisis circumstances. The result of the application of this comprehensive project risk management method under Scrum conditions is an increase in the efficiency of projects due to the minimization of the influence of the human factor, a reduction of losses in the project and overspending of resources.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

Funding

The study was conducted without financial support.

Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

References

1. Hong, B., Ly, M., Lin, H. (2023). Robotic Process Automation Risk Management: Points to Consider. Journal of Emerging Technologies in Accounting, 20 (1), 125–145. https://doi.org/10.2308/jeta-2022-004
2. Practice Standard for Project Risk Management (2009). Project Management Institute, 116.
3. Verma, K. K., Ospanova, A. (2022). Risk Management. International Journal of Innovative Research in Science Engineering and Technology, 11 (12), 14315.
4. A Guide to the Project Management Body of Knowledge (2013). Project Management Institute, 589.
5. Benov, D. M. (2016). The Manhattan Project, the first electronic computer and the Monte Carlo method. Monte Carlo Methods and Applications, 22 (1), 73–79. https://doi.org/10.1515/mcma-2016-0102
6. Freedman, D. (2009). Statistical Models: Theory and Practice. Cambridge University Press. https://doi.org/10.1017/cbo9781139165495
7. Stulp, F., Sigaud, O. (2015). Many regression algorithms, one unified model: A review. Neural Networks, 69, 60–79. https://doi.org/10.1016/j.neunet.2015.05.005
8. Leha, Yu. H., Prokopenko, T. O., Danchenko, O. B. (2010). Ekspertni protsedury ta metody pryiniattia rishen v investytsiynykh proektakh. Visnyk ChDTU, 2, 69–73.
9. Prokopenko, T., Lavdanska, O., Povolotskyi, Y., Obodovskyi, B., Tarasenko, Y. (2021). Devising an integrated method for evaluating the efficiency of scrum-based projects in the field of information technology. Eastern-European Journal of Enterprise Technologies, 5 (3 (113)), 46–53. https://doi.org/10.15587/1729-4061.2021.242744
10. Prokopenko, T., Lanskykh, Y., Prokopenko, V., Pidkuiko, O., Tarasenko, Y. (2023). Development of the comprehensive method of situation management of project risks based on big data technology. Eastern-European Journal of Enterprise Technologies, 1 (3 (121)), 38–45. https://doi.org/10.15587/1729-4061.2023.274473
11. Glowka, G., Hule, R., Zehrer, A. (2024). Risk perception of SMEs: strategic risks, family-related risks, external risks. Risk Management, 26 (4). https://doi.org/10.1057/s41283-024-00148-2
12. Abbas, D. S., Ismail, T., Taqi, M., Yazid, H. (2021). Determinants of enterprise risk management disclosures: Evidence from insurance industry. Accounting, 7 (6), 1331–1338. https://doi.org/10.5267/j.ac.2021.4.005
13. Willumsen, P. L., Oehmen, J., Selim, H. M. R. (2024). Project risk management in practice: the actuality of project risk management in organizations. International Journal of Managing Projects in Business, 17 (4/5), 593–617. https://doi.org/10.1108/ijmpb-09-2023-0214

14. Tak, A., Sunil Chahal, S. C. (2024). Risk Management in Agile Al/Ml Projects: Identifying and Mitigating Data and Model Risks. Journal of Technology and Systems, 6 (3), 1–18. https://doi.org/10.47941/jts.1824
15. Prokopenko, T., Grigor, O. (2018). Development of the comprehensive method to manage risks in projects related to information technologies. Eastern-European Journal of Enterprise Technologies, 2 (3 (92)), 37–43. https://doi.org/10.15587/1729-4061.2018.128140
16. Taber, W. R. (1994). Fuzzy Cognitive Maps Model Social Systems. Artificial Intelligence Expert, 9, 18–23.
17. Liu, Z.-Q., Zhang, J. Y. (2003). Interrogating the structure of fuzzy cognitive maps. Soft Computing – A Fusion of Foundations, Methodologies and Applications, 7 (3), 148–153. https://doi.org/10.1007/s00500-002-0202-x
18. Kosko, B. (1986). Fuzzy cognitive maps. International Journal of Man-Machine Studies, 24 (1), 65–75. https://doi.org/10.1016/s0020-7373(86)80040-2
19. Prokopenko, T. O., Ladaniuk, A. P. (2015). Informatsiyni tekhnolohiyi upravlinnia orhanizatsiyno-tekhnolohichnymy systemamy. Cherkasy: Vertykal, vydavets Kandych S.H., 224.
20. Sawaragi, T., Iwai, S., Katai, O. (1986). An integration of qualitative causal knowledge for user-oriented decision support. Control Theory and Advanced Technology, 2, 451–482.
21. Fedyk, O., Fedyk, S. (2024). Project Risk Management: modern trends and effective practices. Visegrad Journal on Human Rights, 6, 45–50. https://doi.org/10.61345/1339-7915.2023.6.8