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DEVELOPMENT OF METHODOLOGY FOR THE CALCULATION OF THE PROJECT INNOVATION INDICATOR AND ITS CRITERIA COMPONENTS

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Abstract. Two main components of the problem studied in the article are revealed. At the practical level, the provision of the convenient tools allowing a comprehensive evaluation the proposed innovative project in terms of its possibilities for inclusion in the portfolio or development program, and on the level of science – the need for improvement and complementing the existing methodology of assessment of innovative projects attractiveness in the context of their properties and a specific set of components. The research is scientifically applied since the problem solution involves the science-based development of a set of techniques, allowing the practical use of knowledge gained from large information arrays at the initialization stage. *The purpose of the study is* the formation of an integrated indicator of the project innovation, with a substantive justification of the calculation method, as a tool for the evaluation and selection of projects to be included in the portfolio of projects and programs. *The theoretical and methodological basis* of the research is the conceptual provisions and scientific developments of experts on project management issues, published in monographs, periodicals, materials of scientific and practical conferences on the topic of research. The tasks were solved using the general scientific and special methods, mathematical modelling methods based on the system approach. *Results*. A balanced system of parametric single indicators of innovation is presented – the risks, personnel, quality, innovation, resources, and performers, which allows getting a comprehensive idea of any project already in the initial stages. The choice of a risk tolerance as a key criterion of the "risks" element and the reference characteristics is substantiated, in relation to which it can be argued that the potential project holds promise. A tool for calculating the risk tolerance based on the use of matrices and vector analysis is proposed. Based on the fuzzy sets theory, a calculation of the "personnel" component is suggested on the basis of the analysis of the conformity factor of execution of potential project operations to the required competencies of the project manager. The suggested technology assessment as a part of a comprehensive indicator of the project innovation, unlike other technologies, considers the compliance of the project product characteristics with the consumers' requirements and the options of a specific project. On the basis of ideal and matrix modelling, a mathematical model is obtained for determining the prospects of realizing consumer's expectations regarding the project product. *Practical implications*. As a result of applying the suggested indicator of innovation, it is possible to obtain the information on the degree of the project innovativeness and risk tolerance, if the available resources are sufficient, whether the set of competencies of a project manager is in compliance with the project works, and whether the project product meets the requirements of the consumers. It is found that the innovation of projects can be considered as necessary and sufficient information for making optimal decisions. Simplicity, ease of use, efficiency, measurability, adaptability of innovation indicator extend its effectiveness in the field of the project management and provide the organization with a new tool for making appropriate management decisions. Application of the integrated project innovation indicator complements the classical methods of analysis of options, increases the effectiveness of the application of project management tools, especially at the stage of project selection to portfolio or program. The results of the research can be used for further development of scientific and methodological foundations to form a balanced system of indicators of innovative projects. The results implementation is a methodological and organizational basis for creating effective systems and technologies for managing the project programs and portfolios.

Key words: project innovation indicator, personnel assessment, quality assessment, risk assessment, project selection criteria

JEL Classification: H43, O22, M59, M110, D81, C65

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1. Introduction

In management and project management, a special attention is given to the problem of effective mechanisms of selecting the projects to portfolios or development programs. After all, despite the heterogeneous nature of projects, the choice of a variety of possible options is not accidental. At the same time, the requirements for portfolios (programs) are reflected in managerial decisions as to which of the projects should be involved in a portfolio or a program.

Thus, the selection and optimal use of innovative projects are one of the key aspects of creating an effective management system. This requires the appropriate methodological and organisational support.

The problem solved by the authors in the study is relevant and significant for the project management. In fact, the challenging issues of determining the content of programs and the composition of portfolios require the creation of appropriate quality mechanisms for effective selection of projects. Under conditions of the inconstancy of the business environment, the availability of numerous risks, limited time, financial, and material resources, tools for selecting the projects on the basis of an integrated indicator, suggested in the study, becomes especially important.

2. The analysis of recent scientific researches and articulation of the problem

Nowadays, there is a large number of approaches to projects selection, both on the basis of qualitative and quantitative indicators (Ohara, 2010), as well as by various integral and multi-criteria indicators, like in the study by Boock and Chau (2013, pp. 76-86). Where a transparent, easy-to-use for all project stakeholders, selection model based on a system of evaluation and cost criteria is represented. At the same time, the researches by Chang and Ishii (2013, pp. 935-948), as well as the study by Kuo, Chang and Chen (2013, p. 335-349) suggest to use the hybrid MCDM model – a multicriteria decision making model based on the combination of DEMATEL technology with ANP and VICOR methods. Katayev in his study (2014, pp. 55-63) considers the integration of critical chain, critical path, and simulation methods with the use of a matrix model of project management, however with regard to labour resources only. Within the research (Morozov and Osetrin, 2009), the approaches to the formation of a projects portfolio are based on integrated indicators in the field of safety. An interesting "prism" model of the filtering process for new projects, taking into account the influence of the criteria for selecting the necessary projects for a particular portfolio is given by Zachko, Rak Y. and Rak T. (2008, pp. 54-61). The authors – Rach, Koliada, and Antonian (2009, pp. 90-101) – suggested a method of evaluation for selecting the projects for a portfolio based on the analytical and hierarchical model. The subject of the study was later researched by Koliada (2010), who represented an effective tool for selecting the projects for a portfolio based on the concept of strategic unity. At the same time, sensitivity of integral index to changes in the incoming indices values. The authors Semko and Oleinikova (2010) suggest the analysis of indicators to form a projects portfolio, taking into account the synergism effect.

In the conditions of information overload and huge supply in the project market, it becomes increasingly difficult to form projects portfolios and programs from a variety of possible options. In connection with the adoption and implementation of an innovative strategy for the development of social and economic relations, this trend will be retained. As the number of projects grows, the development of an effective project selection tool will definitely remain relevant in the coming years.

In view of the above, it is suggested to use the tool for solving the identified problems based on the use of integrated comprehensive indicators of the project innovation. In contrast to the available indicators, it allows making a comprehensive assessment of risk tolerance, the effect of innovations, the degree of compliance of managing personnel's competencies with the work, and the project product quality with the consumers' expectations at the initial stages. Therefore, it will make it possible to reduce the number of redundant projects and simplify the procedure for rejecting the projects that do not meet the requirements.

3. Goal and objectives of the study

The purpose of the study is the formation of an integrated indicator of the project innovation, with a substantive justification of the calculation method, as a tool for the assessment and selection of the projects to be included in the projects portfolio and programs.

To achieve this goal, the following tasks shall be addressed:

– to design and define the methodology for calculating the integrated indicator of the project's innovation and the balanced system of its criteria components;
– to present a methodology for calculating the criteria component – "risks";
– to describe the method of calculation of the criteria component – "managing personnel";
– to determine the methodology for calculating the criteria component – "quality".

4. Materials and methods of research of the project assessment system

The problem under study includes two main components. At the practical level, the provision of the convenient tools allowing a comprehensive evaluation the proposed innovative project in terms of its possibilities for inclusion in the portfolio or development program. At the level of science, there is a need for improving and complementing the existing methodology of assessment of innovative projects attractiveness in the context of their properties and a specific set of components. The research is scientifically applied since the problem solution involves the development of a set of techniques, allowing the practical use of knowledge gained from large information arrays at the initialization stage.

One of the problem's solutions has been suggested in the study (Malyi, Antonenko, Mazurkevych, 2008), where the innovation of the project is regarded as the amount of information necessary and sufficient to obtain the optimal solution in the course of the project implementation. According to the source (Kutsekon, 2009), the resulting effect of any innovative activity is the production of a competitive product, strengthening of the position of an enterprise in the market and of the financial state of a company. With such an approach, choosing the best variant of the innovative project to be included in a portfolio involves getting great results at minimum cost.

By its essence, economic indicators are resultant, other groups' indicators are indicative, they help to identify the causes of problems and prevent the consequences. There are a number of general rules for using alternative projects selection criteria; however, each enterprise has its own system of priorities. For example, the project's compliance with the chosen strategy, completion time, social significance, market potential of the product, impact on the company's image, level of risk, etc.

As the choice of any set of projects in the future provides a balance or imbalance of the entire portfolio or program, the creation of an effective system of projects assessment is of great importance and involves the use of a number of indicators. Therefore, it seems advisable to use the project innovation indicator, which is formed on the basis of a comprehensive system of indicators (criteria).

5. Calculation of the integrated project innovation indicator and its criterion components

Integrated (group) factorial indicator of the project innovation (w) is defined as the sum of the products of parametric single (in some cases – expert) assessments (d_i) and weight coefficients of the indicators being analysed (g_i) using the formula:

$$w = \sum_{i=1}^{n} d_i * g_i, \quad (1)$$

where d_i is the value of i indicator of the assessment;
g_i is the weight coefficient of i indicator;
p is the number of assessment indicators.

Based on the results of previous studies, the components of the index of innovativeness of the project include the following criteria: risks, managing personnel, quality, innovation, resources and performers (subcontractors). In the limited volume of this work, consider in detail the methodology for calculating the first three of the six specified components.

World experience and business practices show the business entities management's awareness of the importance of taking into account the risks as the elements of management strategies for a capital increase in the total value of the enterprise (Arseniev, Davydova, 2017). This, according to Martin and William (2000), is an assessment of the performance and criterion of prospects for the economic growth and owners' welfare. So, let us consider the first criteria component of creating the indicator of project innovation – "Risks".

Quantitative assessment of potential risks is an integral part of the project selection stage. It provides a determination of the probability of risks occurrence and the possible impact of their consequences on the project. In this case, the measures chosen on the basis of risk assessment can be aimed at the risk mitigation directly, the elimination of risk factors or at the control of the economic consequences (Fig. 1).

In practice, risk assessments are often based on a simplified model – several or one main indicator, representing the most important characteristics inherent in this project.

As a key criterion, we suggest a choice of project tolerance for possible risks. In particular, the risk tolerance (ability to withstand the business destabilization processes due to certain characteristics) will be assessed using matrices and vector analysis.

Suppose we have m projects described by n categories of risk. Then each of considered projects m can be interpreted as a point of a n-dimensional risk space with coordinates equal to the value of n risk categories for the selected project. Below are the acceptable risk assessments (value X_{ij} where i is the index of the project, and j is the index of the project risk category).

Projects	Risk Assessments						
	Risk 1	Risk 2	Risk 3	…..	Risk *j*	….	Risk *N*
Project 1	X_{11}	X_{12}	X_{13}	…	X_{1j}	…	X_{1n}
Project 2	X_{21}	X_{22}	X_{23}	…	X_{2j}	…	X_{2n}
Project 3	X_{31}	X_{32}	X_{33}	…	X_{3j}	…	X_{3n}
… …	…	….	….	…	…	…	…
Project *i*	X_{i1}	X_{i2}	X_{i3}	…	X_{ij}	…	X_{in}
… …	…	…	…	…	…	…	…
Project *m*	X_{m1}	X_{m2}	X_{m3}	…	X_{mj}	…	X_{mn}

Assessments of the risk category may be heterogeneous due to the fact that the risk factors are manifested differently in projects of different types. Therefore, in order to eliminate the perversion in the further analysis that may be caused by this, it is necessary to carry out a preliminary procedure for standardizing risk assessments. This procedure involves the replacement of assessments of X_{ij}, with Z_{ij} assessments, calculated using the formula:

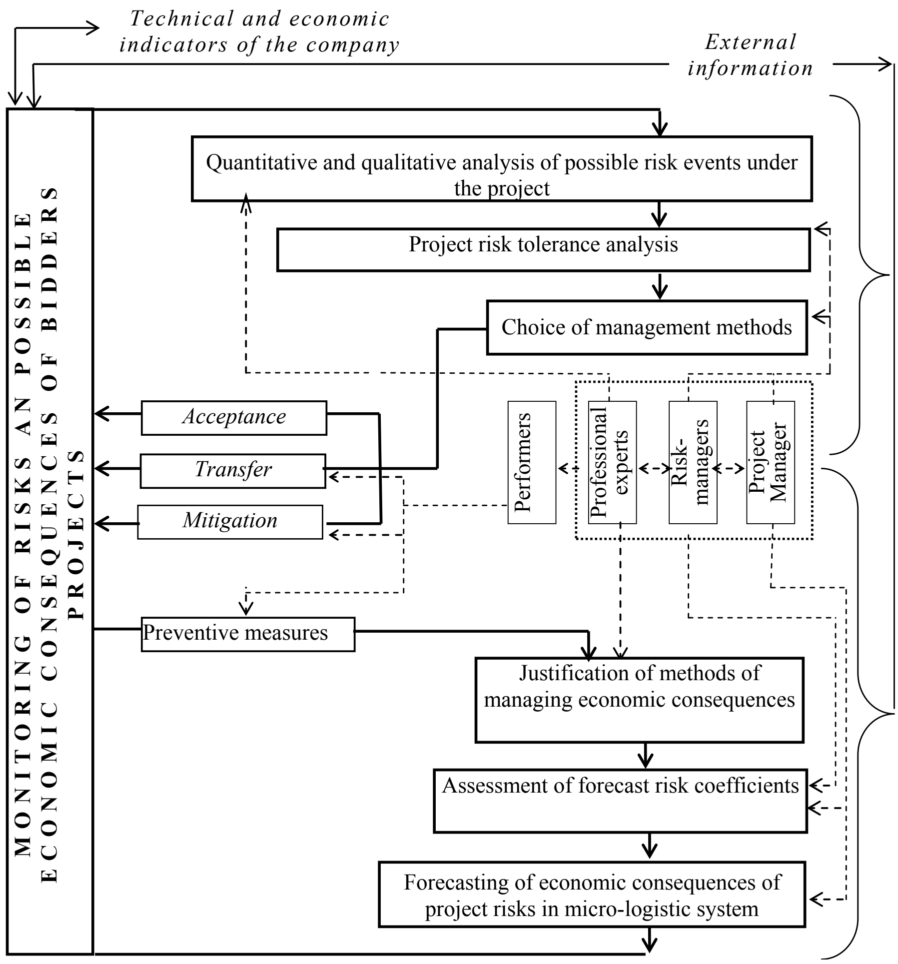

Fig. 1. Bidder projects risk monitoring system

$$Z_{ij} = \frac{X_{ij} - \overline{X_j}}{\sigma_j}, \tag{2}$$

where

$$\overline{X_j} = \frac{1}{m}\sum_{i=1}^{n} X_{ij}, \tag{3}$$

and

$$\sigma_j = \left[\frac{1}{m}\sum_{i=1}^{n}(X_{ij} - \bar{X}_j)^2\right]^{\frac{1}{2}}, \tag{4}$$

where $j = 1,2,3 \ldots, n$; $i = 1,2,3 \ldots, m$; X_{ij} are the values of the risk category j for the project i; $\overline{X_j}$ is the arithmetic mean of the risk category j; σ_j is the standard deviation of the risk category j; Z_{ij} is the standardized value of the risk category j for the project i.

In order to make an appropriate management decision regarding the selection of a project, it is necessary to select its reference characteristic, regarding which it can be argued that this project holds promise. Also, the project with a minimal risk can be chosen as a reference. Then Z_{0j} is a standardized value of the risk category j for the project 0 will be defined as the minimum among all values for this category of risk:

$$Z_{0j} = \min_i Z_{ij}. \tag{5}$$

The distance between individual projects and the reference project in the area of standardized risk assessments will be determined as follows:

$$C_{i0} = \left[\sum_{j=1}^{n}(Z_{ij} - \overline{Z_{0j}})^2\right]^{\frac{1}{2}} (i = 1, 2, 3, \ldots m). \tag{6}$$

Upon the calculation of the distances between all the projects and the reference project in space, a vector of distances is obtained, which can be represented as follows:

$$C = \begin{pmatrix} C_{10} \\ C_{20} \\ \\ C_{i0} \\ \\ C_{m0} \end{pmatrix}. \tag{7}$$

The resulting distances are the initial values for calculating the risk tolerance index D_i for each i-th project:

$$D_i = 1 - \frac{C_{i0}}{C_0}, \tag{8}$$

$$C_0 = \overline{C_0} + 2S_0, \tag{9}$$

$$\overline{C_0} = \frac{1}{m}\sum_{i=1}^{m} C_{i0}\ , \tag{10}$$

$$S_0 = \left[\frac{1}{m}\sum_{i=1}^{m}(C_{i0} - \overline{C_0})^2\right]^{\frac{1}{2}}, \tag{11}$$

where $i = 1,2,3 ..., m$; D_i is the risk tolerance index; C_0 is the vector of distances of i project; $\overline{C_0}$ is the arithmetic mean of the vector of distances of i project; C_{i0} is the distance between individual projects and the reference project; S_0 is the standard deviation of the vector of distances of *i* project; *m* is the number of projects to be assessed.

The closer the value of the risk tolerance indicator of the project to 1, the more promising the project. The limit value at the stage of making a decision on the selection of projects by the risk indicator is the arithmetic mean of the risk tolerance level:

$$\overline{D} = \frac{1}{m}\sum_{i=1}^{m} D_i\ . \tag{12}$$

Thus, with an assessment by different risk categories for each potential project, using taxonomic analysis of the set of estimates, it is possible to divide the projects into 2 subsets – the promising ones and those showing no promise.

Consider the following criteria component of creating the project innovation indicator – "personnel". In particular, using the theory of fuzzy sets, an analysis of the coefficient of compliance of the potential project operations performance with the required competence of the project manager is suggested.

Suppose that $X = \{x_1, x_2, x_3\}$ is a set of project operations, $Y = \{y_1, y_2, y_3\}$ is a set of functions performed due to a certain competence, $Z = \{z_1, z_2, ..., z_m\}$ - is the set of competencies of the project manager required for the project implementation.

ΦR:: $X \times Y \to [0,1]$ is the membership function of the fuzzy binary relation *R*.

For all $x \in X$ and all $y \in Y$ function $FR\ (x,\ y)$ is the degree of significance of a certain function execution (functional significance) for the performance of the relevant work when selecting the key competencies of the project.

Relation *R* in matrix form:

	y_1	y_2	...	y_p
x_1	$\Phi_R(x_1, y_1)$	$\Phi_R(x_1, y_2)$	...	$\Phi_R(x_1, y_p)$
$R = x_2$	$\Phi_R(x_2, y_1)$	$\Phi_R(x_2, y_2)$	...	$\Phi_R(x_2, y_p)$
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
x_n	$\Phi_R(x_n, y_1)$	$\Phi_R(x_n, y_2)$	...	$\Phi_R(x_n, y_p)$

Suppose that π: $Y \times Z \to [0,1]$ is a membership function of the fuzzy binary relation *S*.

For all $y \in Y$ and all $z \in Z$ $\pi_s\ (y,\ z)$ is the degree of membership or the degree of compatibility of the key competency with functional significance. Then in the matrix form, this relation is as follows:

	z_1	z_2	...	z_m
y_1	$\pi s(y_1, z_1)$	$\pi s(y_1, z_2)$	...	$\pi s(y_1, z_m)$
$S = y_2$	$\pi s(y_2, z_1)$	$\pi s(y_2, z_2)$	...	$\pi s(y_2, z_m)$
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
y_p	$\pi s(y_p, z_1)$	$\pi s(y_p, z_2)$	...	$\pi s(y_p, z_m)$

The relation $T: x \times Z \to [0,1]$ is obtained, the elements of which are defined by the following membership function:

$$\mu_{Ai}(x, z_i) = \frac{\sum_y \Phi_R(x, y) \cdot \pi s(y, z_i)}{\sum_y \Phi_R(x, y)}$$

for all $x \in X, y \in Y, z \in Z$. (13)

The relation T in the matrix form:

	z_1	z_2	...	z_m
x_1	$\mu_{A1}(x_1, z_1)$	$\mu_{A2}(x_1, z_2)$	...	$\mu_{Am}(x_1, z_m)$
$T = x_2$	$\mu_{A1}(x_2, z_1)$	$\mu_{A2}(x_2, z_2)$	...	$\mu_{Am}(x_2, z_m)$
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
x_n	$\mu_{A1}(x_n, z_1)$	$\mu_{A2}(x_n, z_2)$	...	$\mu_{Am}(x_n, z_m)$

The sum $\sum_y \Phi_R(x, y)$ is equal to the degree of a fuzzy subset of functional significance *y*, indicating the level *x*, which is used in the study to assess key competencies *z*, $\mu_{Ai}(x, z_i)$. The function z_i can be interpreted as a weighted degree of necessity of availability of a competence to perform the work *x*. For all x_1 and x_2 of all $z \in Z$ and all $\lambda \in [0.1]$, this function meets the condition:

$$\mu_{Ai}\left[\lambda(x_1, z_i) + (1 - \lambda(x_2, z_i))\right] \geq$$

$$\geq \min\left[\mu_{Ai}(x_1, z_i), \mu_{Ai}(x_2, z_i)\right], \tag{14}$$

where λ is the size of the class interval, which will be calculated as follows:

$$\lambda = \frac{z_{\max} - z_{\min}}{K}\ , \tag{15}$$

where *K* is the number of classes, into which the variation of a sign should be split.

For example, the number of competencies is 5-20 – the number of classes is 5, or the number of competencies is 20-35 – the number of classes is 7.

	z_1, z_2	z_1, z_3	…	z_{m-1}, z_m
x_1	$\mu_{A1}(x_1,z_1)\wedge\mu_{A2}(x_1,z_2)$	$\mu_{A1}(x_1,z_1)\wedge\mu_{A2}(x_1,z_3)$	…	$\mu_{Am}(x_1,z_{m-1})\wedge\mu_{Am}(x_1,z_m)$
$W = x_2$	$\mu_{A1}(x_2,z_1)\wedge\mu_{A2}(x_2,z_2)$	$\mu_{A1}(x_2,z_1)\wedge\mu_{A2}(x_2,z_3)$	…	$\mu_{Am}(x_2,z_{m-1})\wedge\mu_{Am}(x_2,z_m)$
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
x_n	$\mu_{A1}(x_n,z_1)\wedge\mu_{A2}(x_n,z_2)$	$\mu_{A1}(x_n,z_1)\wedge\mu_{A2}(x_n,z_3)$	…	$\mu_{Am}(x_n,z_{m-1})\wedge\mu_{Am}(x_n,z_m)$

At the same time, it should be noted that all $\mu_{Ai}(x, z_i)$ are convex. And hence their overlap is convex functions as well.

Let us determine the condition, by which the threshold for the distribution of project operations will be limited, taking into account the key competencies of the project manager

$$l < \min_{i,j}\max_{x}\min\left[\mu_{Ai}(x,z_i),\mu_{Ai}(x,z_j)\right]. \quad (16)$$

Then

$$M_i = \left\{x \left| \mu_{Ai}(x) \ge \min_{i,j}\max_{x}\min\left[\mu_{Ai}(x,z_i),\mu_{Ai}(x,z_j)\right]\right.\right\}$$

for all $x \in M_i$. (17)

In this way, we obtain a level set that describes operations, focused on a certain key competence.

Subsequently, if the project is classified as a low or inappropriate level of competence of a project manager, a decision is made to review the composition of the team – in particular, the selection of a project manager, experienced in the field of the project issues. In case the replacement is not possible, the decision to reject the project may be made. However, provided that analytical data on other components of the project innovation indicator are taken into account.

Let us turn to the next component of the suggested indicator – "quality". In a market economy, the level of production performance can be considered as a measure of satisfaction of consumers' needs at the minimum cost. At the same time, the key characteristic that shapes the needs of consumers in a competitive environment is the quality of projects product or products. The assessment of the quality of carrying out the processes of the project activity and production is possible using various methods – differential, generalization, comprehensive, instrumental, statistical, etc. Each of them has certain advantages and disadvantages.

The calculation of the "quality" indicator according to the ideal matrix modelling (Mazurkevich, 2009) is suggested on the basis of assessing the quality level of the project product in relation to the consumer's requirements for the product.

This interconnection is illustrated in Fig. 2

Suppose, $X = \{x_1, x_2 \ldots, x_n\}$ is the set of project operations (the technological capabilities of the organisation used to obtain the product);

$Y = \{y_1, y_2, \ldots y_p\}$ – a set of project product characteristics;

$Z = \{z_1, z_2, \ldots z_m\}$ – a set of consumer requirements for the product.

$\Phi_R : X \times Y \to [0,1]$ – a membership function of a fuzzy binary relation R (in matrix form – $\|\Phi_R(x, y)\|$). For all $x \in X$ and all $y \in Y$ function $FR(x, y)$ is the degree of significance of carrying out a specific operation to implement the relevant characteristic of the project product.

$\pi: Y \times Z \to [0,1]$ is the membership function of the fuzzy binary relation S. For all $y \in Y$ and all $z \in Z$ $\pi s(y, z)$ is the degree of membership or the degree of compatibility of product characteristics with the consumer requirements for this product. Then in the matrix form this relation is as follows: $\|\pi_S(y, z)\|$.

The relation $T: X \times Z \to [0,1]$ is obtained, the elements of which are defined by the following membership function

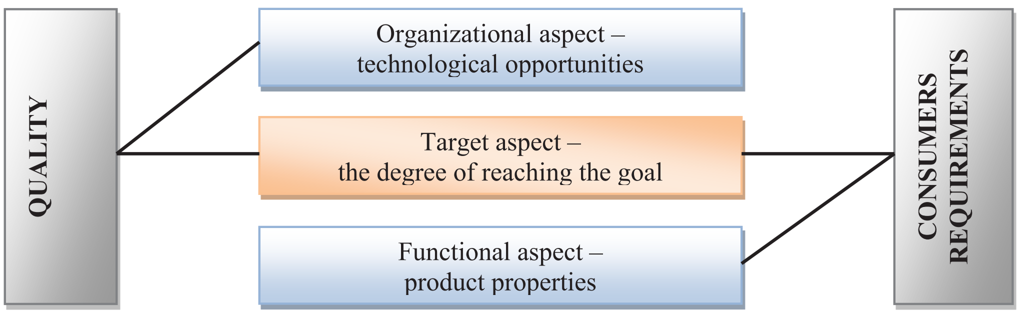

Fig. 2. Interconnection of quality with consumer requirements for the project product

$$\mu_{Ai}(x,z_i)=\frac{\sum_y \Phi_R(x,y)\cdot \pi s(y,z_i)}{\sum_y \Phi_R(x,y)}$$

for all $x\in X, y\in Y, z\in Z$. (18)

Then in the matrix form, this relation is as follows: $\|\mu_A(x,z)\|$.

Thus,

$$\frac{\sum \mu_A(x,z)}{\sum \mu_A(x,z)_{Еталон}}\times 100\%, \qquad (19)$$

determines the organization's ability to implement the expectations of consumers about this product, that is, determines the quality of the product for a particular consumer.

$\sum \mu_{A_i}(x,z)_{Еталон}$ It is calculated using the formula:

$$\sum \mu_{Ai}(x,z_i)_{Еталон}=\sum\left(\frac{\sum_y \Phi_R(x,y)_{Еталон}\cdot \pi_S(y,z_i)_{Еталон}}{\sum_y \Phi_R(x,y)_{Еталон}}\right)$$

for all $x\in X, y\in Y, z\in Z$, (20)

$$\left(\sum \mu_{Ai}(x,z_i)\Big/\sum\left(\frac{\sum_y \Phi_R(x,y)_{Еталон}\cdot \pi_S(y,z_i)}{\sum_y \Phi_R(x,y)_{Еталон}}\right)\right)\times 100\%$$

for all $x\in X, y\in Y, z\in Z$ (21)

The second relation is matching the needs:

$$\left(\sum \mu_{Ai}(x,z_i)\Big/\sum\left(\frac{\sum_y \Phi_R(x,y)\cdot \pi_S(y,z_i)_{Еталон}}{\sum_y \Phi_R(x,y)}\right)\right)\times 100\%$$

for all $x\in X, y\in Y, z\in Z$ (22)

The suggested technology of quality assessment as a part of a comprehensive indicator of the project innovation, unlike other technologies, considers the compliance of the project product characteristics with the consumers' requirements and the options of a particular project. Such information is extremely important for the manager at the stage of making a decision on the inclusion of a potential project in a projects portfolio or a program.

In the next steps, the project manager calculates the data of three other components of the integrated project

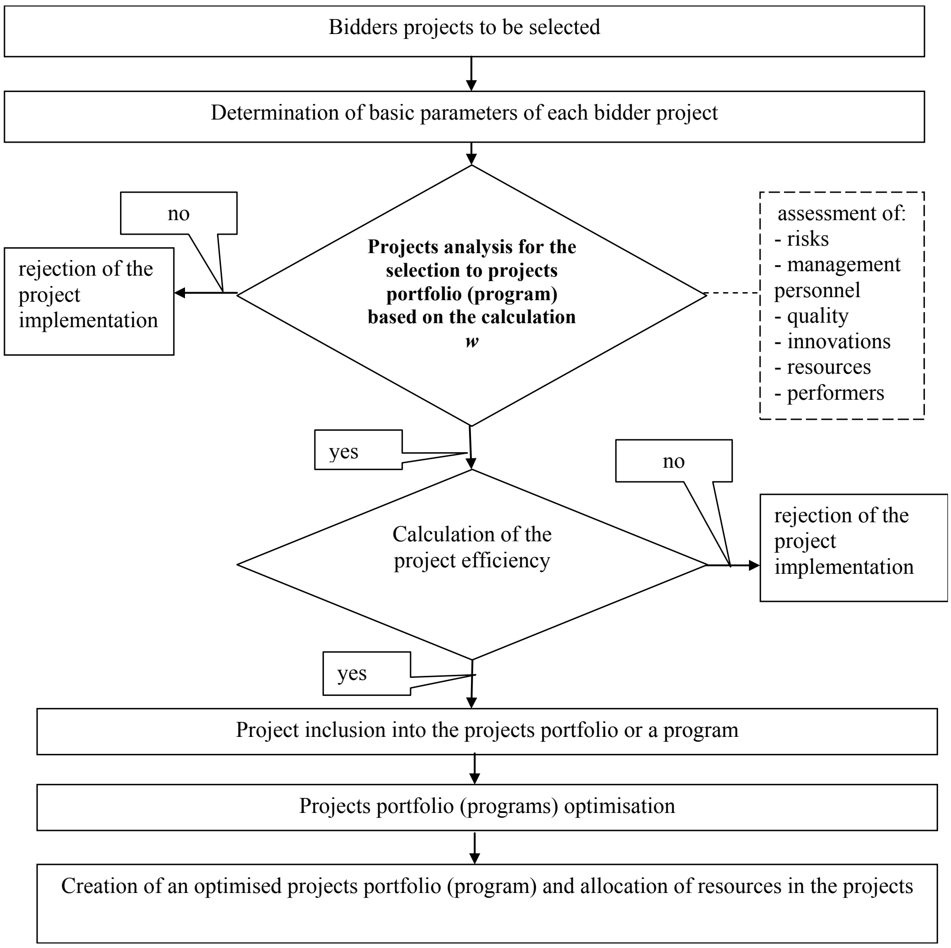

Fig. 3. The place of the integrated indicator of the project innovation in the algorithm of the projects portfolio or program creation

innovation indicator – "resources", "innovations" and "performers". As a result, the matrix consisting of numbers from 0 to 1 is obtained. Since the value of the ideal matrix should be 0, then this is a priority option, while the matrix with the value of 1 is the inadmissible option. Further using the given formula (1), the project innovation indicator is directly defined.

Fig. 3 shows the place of the developed indicator of projects innovation in the general algorithm of the project portfolio (program) creation.

The developed methods for project selection based on the innovation indicator considers the project portfolio and the program as a system of ordered elements and allows for simplification of the screening procedure and the reduction of the number of "redundant" projects, and thus provides the organization with an entirely new tool for making appropriate management decisions on the issue of assessment and choices.

It can be argued that the use of a project innovation indicator will complement the classical project selection tools to project portfolios or development programs. However, at the same time, all the criteria must be defined and approved by senior management, the limitations should be established by the appropriate departments, all analytical project data shall be recorded in the relevant documents, potential conflicts between projects must be timely discovered and eliminated. The created projects portfolio/program in the future should be checked for sensibility and go through the process of optimization. For example, using the recurrence relation of Richard Bellman.

However, it should be noted that some of its components can be calculated on the initial stages using the expert method only, which slightly reduces the accuracy of results. This method of individual expert estimations is based on the expression of expert opinions independently of each other and on the use of these opinions as the final result of the expert evaluation. However, this disadvantage may be neutralized or minimized. In order to do this, in the course of processing the results of the expert survey, the expert opinions consistency analysis is required using a concordance coefficient. The confidence estimation of the expert survey results must also be carried out using a Delphi method.

7. Conclusions

To date, there are numerous approaches to the selection of projects both on the basis of qualitative and quantitative indicators. Methods for project financing analysis, scenario methods, optimization, cost-benefit method, and other methods can be used for the assessment and option selection. Summarizing the results, it is worth noting that the use of the project innovation indicator for this purpose is feasible as it has certain advantages. Among them are: simplicity, ease of use, performance, measurability, and adaptability. All of its components are available to the manager or the project manager at an early stage, and they allow getting a comprehensive overview of the project. The above complements the classical methods of alternative analysis, increases the efficiency of the application of the project management tools, especially at the stage of project selection to a portfolio or a program.

According to the tasks, the following conclusions are obtained:

1. An integrated factorial projects innovation indicator is created, which is defined as the sum of the results of parametric single estimates and weight coefficients of the factors under analysis. Based on the review conducted by the existing indicators of project selection and the results of previous studies, suggested the following composition of criteria for defining the projects innovation indicator: risks, personnel, quality, innovation, resources and performers. According to the authors, these components are optimal in terms of the completeness of the scope of potential projects analysis for the involvement in a particular program or projects portfolio. After all, as a result of the application of the suggested innovation indicator, it is possible to obtain information on the degree of innovation and risk tolerance of the project. And whether there are sufficient resources available, if the project manager's set of competencies meets requirements of the project operations, and whether the project product is in compliance with requirements of customers. It is found that the innovation of projects can be considered as necessary and sufficient information for making optimal decisions. And since this value is non-dimensional, there is the possibility of comparing different projects to each other and making appropriate managerial decisions, based on a particular, measurable characteristic.

2. Risk tolerance is selected as the key criterion for the "risks" component and the reference characteristic, in relation to which it can be argued that this project holds promise. After all, the ability to withstand the current destabilization processes of a business environment due to particular characteristics is one of the most important qualities. A tool for calculating the risk tolerance based on the use of matrices and vector analysis is suggested. It is found that since the risk category estimates may be heterogeneous, in order to eliminate the perversion, it is necessary to carry out a procedure for their standardization. The limit value at the stage of making a decision on the selection of projects by the risk indicator is the arithmetic mean of the risk tolerance level. Thus, the closer the value of the indicator of the project risk tolerance to 1, the more promising the project will be considered.

3. The calculation of the "personnel" component is presented based on the analysis of the coefficient of compliance of potential project operations with the required competencies of the project manager, employing

the theory of fuzzy sets. An algorithm for determining the conditions, limiting the threshold of the project works distribution, considering the key competencies of the project manager, is provided. An equation for describing the work focused on a certain key competence is obtained. The criterion for making a positive decision on the selection of projects by the "personnel" indicator will be the maximum correspondence of a set of competencies of the project manager to a set of certain project operations, or vice versa.

4. The calculation of "quality" component on the basis of ideal-matrix simulation is proposed. A mathematical model for determining the prospects of implementing consumers' expectations regarding the project product is obtained. Therefore, the suggested technology of quality assessment as a part of a comprehensive project innovation indicator, unlike other technologies, considers the compliance of the project product characteristics with the consumers' requirements and the options of a particular project. The best project will be the one with the maximum degree of significance of a particular work to implement the appropriate characteristics of the project product and the maximum degree of compatibility of product characteristics with the consumer requirements for this product.

The results of the research can be used for further development of scientific and methodological foundations to form a balanced system of indicators of innovative projects. The implementation of the results obtained represents a methodological and organizational basis for creating effective systems and technologies for managing the programs and project portfolios both at the level of individual enterprises and at the regional level.

The next step in this study may be the application of the suggested innovation indicator, as one of the components of the mathematical model for calculation of projects clusters, because the need to activate the innovation factor under conditions of significant regional inequality stimulates interest in the theory of innovative regional clusters. Thus, with the availability of a certain cluster of projects that may be included in the program, it is necessary to conduct the qualitative and quantitative selection of projects. At the same time, qualitative selection can be started by constructing a matrix of combined criteria and project distribution within this matrix. Such a matrix can be created for a combination of such criteria as: "the project innovation indicator – profit" or "the project innovation indicator – profitability".

References:

Arsenyev, Ya. N., & Davydova, T. Ya. (2017). Problem business risk management. Topical questions of contemporary science, Aspekt Publishing, 41.

Boock, M. H., & Chau, M. (2013). The Use of Value Engineering in the Evaluation and Selection of Digitization Projects. Evidence Based Library and Information Practice, 2(3), 76-86.

Chang, Y. F., & Ishii, H. (2013). Probing the Implementation of Project Management Office by Using DEMATEL with a Hybrid MCDM Model. Journal of Japan Society for Fuzzy Theory and Intelligent Informatics, 25(6), 935-948.

Kataev, D. S. (2014). Matrichnoe upravlenie trudovyimi resursami promyishlennyih predpriyatiy. Upravlinnya proektami ta rozvitok virobnitstva, 1(49), 55-63.

Kolyada, O. P. (2010). Instrumentalnyi zasib vidboru proektiv u portfel vyshchoho navchalnoho zakladu v ramkakh kontseptsii stratehichnoi yednosti. Vostochno-Evropeiskyi zhurnal peredovykh tekhnolohyi,1/2 (43), 31.

Kuo, Sh.-Y., Chang, K.-W., & Chen Sh.-Ch. (2013). Decision-making on Transport Policy: A Comparison between Scholars and Stakeholders. Journal of the Eastern Asia Society for Transportation Studies, 10, 335-349.

Kutsekon, L. O. (2009). Innovatsiyi yak obektivna neobhidnist zabezpechennya konkurentospromozhnosti ekonomiki. Strategiya innovatsiynogo rozvitku ekonomiki ta aktualni problemi menedzhment-biznes osviti, 191-194.

Maliy, V. V., Antonenko, S. V., & Mazurkevich, A. I. (2008). Riven innovatsiynosti proektu. Upravlinnya proektami ta rozvitok virobnitstva, 1(25), 9-12.

Martin, J., & William, P. (2000). Value Based Management. The Corporate Response to the Shareholder Revolution. Harvard Biasness School Press, 249.

Mazurkevich, A. I. (2009). Model otsenki kachestva. Upravlinnya proektami stan ta perspektivi, 127-128.

Morozov, V. V., & Osetrin, K. M. (2009). Rozrobka modeli formuvannya portfelya budivelnih proektiv. Upravlinnya proektami stan ta perspektivi, 59-60.

Ohara, Sh. (2010). The Logical Context and Evolution of P2M Program Life Cycle Management: In Pursuit of Sustainable and Seamless Innovation in Global Competition. Journal of International Association of Project & Program Management, 5, 23-40.

Rach, V. A., Kolyada, O. P., & Antonyan, E. A. (2009). Metod invariantnyih pokazateley opisaniya strategiy razvitiya kak instrument formirovaniya portfelya proektov. Upravlinnya proektami ta rozvitok virobnitstva, 2(30), 90-101.

Semko, I. B., & Olenikova, T. Yu. (2010). Sinergetichniy efekt portfelya proektiv. Vostochno-Evropeiskyi zhurnal peredovykh tekhnolohyi,1/2 (43), 60-62.

Zachko, O. B., Rak, Yu. P., & Rak, T. Ye. (2008). Pidkhody do formuvannia portfelia proektiv udoskonalennia systemy bezpeky zhyttiediialnosti. Upravlinnya proektami ta rozvitok virobnitstva, 3(27), 54-61.