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ANALYSIS OF PRACTICAL APPLYING OF PROJECT SELECTION METHOD BASED ON THE POSSIBILITY THEORY

Виконана практична апробація методу відбору проектів на базі теорії можливостей. Розглянуто в термінах теорії можливостей характеристики розглянутих проектів і вимоги до них. Здійснено відбір проекту, супроводжуваний графічними інтерпретаціями операцій в рамках нечіткої логіки. Графічним чином продемонстрований аналіз впливу на вибір проекту таких характеристик, як «достовірність» і «можливість».

Ключові слова: *метод відбору проектів, трапецієподібні числа, функція приналежності, теорія можливостей, «фільтрація» проектів.*

1. Introduction

The selection of projects from a variety of alternative options is one of the central problems in project management. The issues of project selection are viewed as investors from the perspective of commercial feasibility of investments, and enterprises that implement their development strategies through projects. The specifics of the essence and conditions of project implementation justify the variety of existing methods and models of project selection, multiprojects, programs and portfolio.

Modern branch markets can be described as «super dynamic», where changes in the market situation occur so dynamically that for their characterization in modern publications the term «Turbulence» is used. Therefore, under the current conditions, the task of selecting projects is solved in a situation for which deterministic approaches prove to be ineffective, since they do not take into account the real dynamics and volatility of the market conjuncture. And, consequently, they can't ensure that the corresponding real situation is obtained.

Under such conditions, methods in project management, based on the theory of fuzzy sets and the possibility theory, have become widespread. A number of modern studies are devoted to the application of this theoretical base to the tasks of project management. Nevertheless, theoretically stated models and methods don't fully reflect the practical aspects of their use, so the appeal to the analysis of the practical application of the project selection method based on the possibility theory is relevant.

2. The object of research and its technological audit

The object of research is project selection method based on the possibility theory.

In order to improve the efficiency of the project selection processes in the turbulent environment, in [1] the authors developed the concept of project selection and its formalization in the absence of completeness of information when making decisions on the project. The concept is based on the «project map» – a structured set of project characteristics. This set forms a set of criteria and restrictions that can be formalized by different methods.

In [1] the proposed concept is formalized on the basis of the possibility theory. Nevertheless, this paper does not reflect practical aspects of the application of this method. Therefore, in order to better understand the essence of the proposed method and to study its applicability in practice, it is necessary to carry out experimental studies related to its empirical verification.

3. The aim and objectives of research

The aim of research is an empirical verification of the project selection method based on the possibility theory, which allows to make decisions in the absence of completeness of information.

To achieve the aim, the following tasks are set:

1. To characterize the main stages and specifics of the project selection method based on the possibility theory.

2. For a specific situation, to generate initial information on projects and implement a procedure for selecting a project in accordance with the proposed method.

4. Research of existing solutions of the problem

The task of making decisions on various aspects of management, including the problem of selecting projects in the absence of completeness of information, is given considerable attention in the modern scientific literature. Many of the proposed approaches are based on fuzzy logic. Examples can be found in [2–11].

In this regard, the following studies should be noted.

In [2] the model of fuzzy choice of projects in the portfolio of projects in the field of education is given. The proposed approach is based on the integral contribution of the project to the integral indicator of the strategic goal. The proposed model, firstly, is focused on the formation of a portfolio of projects; secondly, it can't be used for commercial enterprises, since it does not take into account financial, commercial and production aspects.

In [3], a model for forming a portfolio of projects of a manufacturing enterprise in a fuzzy formulation is developed, the basis of the approach is an integral fuzzy project evaluation, reflecting its various aspects – marketing, organizational, resource, etc. As in the previous situation, the model is focused on portfolio formation, to which specific requirements are made.

In [4], an algorithm is proposed for selecting projects for a research agency, attention is focused on the objectives of research projects, while fuzzy mathematics is used to form an integral evaluation of projects. Work [5] is also devoted to a specific category of projects. Within the framework of this study, the scheme of application of fuzzy logic for project selection is considered, and attention is focused on the mathematical aspect of the proposed approach. In the study [6], the authors analyze software for implementing models of fuzzy project selection. In [7] the decision-making on investments is also based on the theory of fuzzy sets.

Despite the fact that problems of project management are not considered in [8, 9], nevertheless, applied application of the theory of fuzzy numbers is demonstrated at a sufficiently high level.

Zadeh possibility theory [10] (fuzzy analog of probability theory) allows to develop solutions in the absence of complete information. In [11], the possibility theory in the modern interpretation is presented, including the model of the formation of the portfolio of projects. On its basis and further development, the approach proposed in [1] is based, the merit of which, among other things, is the possibility of not only choosing but also analyzing «what will happen if…» to determine the project's compliance with requirements.

5. Methods of research

The study is conducted in accordance with the methodology of the system approach. The basic method is the apparatus of the possibility theory, formulated on the basis of fuzzy logic and the use of fuzzy numbers of the trapezoid type.

6. Research results

As mentioned above, this research is based on the method of project selection based on the possibility theory. The basic object of the proposed approach is the «project map», by which we will understand a set of project characteristics that are relevant when making decisions on the selection of projects in a specific situation. To take into account the interval value of each characteristic, it is proposed to use fuzzy numbers of a trapezoidal type. This kind of numbers allows to take into account the optimistic, pessimistic and most probable values of the characteristics, in this case, of the project.

For practical approbation of the approach proposed in [1], let's consider the following initial data for three alternative projects (Table 1).

Further, a lot of conditions and criteria are formed, which can also be specified in the form of fuzzy conditions.

In publications on the possibility theory [11], two types of fuzzy restrictions are proposed, used in operations with trapezoidal and triangular fuzzy numbers. Limitations in the form of an indistinct number of $B=(0,0,b_3,b_4)$ type correspond to restrictions from above (otherwise, budget constraints) and characterize the possible limits of resource use. Here $[b_3,b_4]$ is the gap that is valid for the resource under consideration, the gap $[0,b_3)$ is the desired interval (the degree of membership is 1).

For the example under consideration, let's set the following unclear restrictions:

1. For financial resources $B^1=(0,0,b_3^1,b_4^1)=(0,0,80,100)$. The meaning of this restriction – the company is ready to allocate 80 thousand c. u., in the extreme case – 100 thousand c. u.

2. According to the project potential (integrated assessment) $B_1^2=(b^{21},b^{21},\infty,\infty)=(0.7,0.7,\infty,\infty)$ – the company does not undertake projects with a project potential of less than 0.7.

3. According to the component of the project potential «Company Assets» $B_2^2=(b^{22},b^{22},\infty,\infty)=(0.6,0.6,\infty,\infty)$ – the company does not undertake projects for which the component of the project potential «Company assets» is less than 0.6.

4. In terms of value $B_3^2=(b^{23},b^{23},\infty,\infty)=(0.75,0.75,\infty,\infty)$ – the value of the project (the final competitiveness) should be at least 0.75 (with the maximum possible estimate of 1).

Fuzzy criterion – NPV project – in terms of fuzzy sets is formulated as follows $K_1=(k^{11},k^{11},\infty,\infty)=(120,120,\infty,\infty)$ – the company expects NPV at a level of 120 thousand c. u.

The criterion can be used both with restrictions and separately after the «filtering» procedure. At the first stage, let's carry out reasoning without taking into account NPV in the system of restrictions.

For each restriction, a confidence level is set (Table 2).

Table 1

Project Maps

Characteristics	Project 1	Project 2	Project 3
Economic efficiency – NPV $E_1^f=(E_{11}^f,E_{12}^f,E_{13}^f,E_{14}^f)$	$E_1^1=(100,120,140,160)$	$E_1^2=(110,120,130,140)$	$E_1^3=(90,120,140,150)$
Value – Competitiveness $V_1^f=(V_{11}^f,V_{12}^f,V_{13}^f,V_{14}^f)$	$V_1^1=(0.75,0.8,0.85,0.9)$	$V_1^2=(0.7,0.75,0.8,0.85)$	$V_1^3=(0.75,0.85,0.85,0.9)$
Resources – Financial resources $R_1^f=(R_{11}^f,R_{12}^f,R_{13}^f,R_{14}^f)$	$R_1^1=(60,62,65,67)$	$R_1^2=(70,74,78,82)$	$R_1^3=(75,80,80,85)$
Integral evaluation of the potential $P^f=(P_1^f,P_2^f,P_3^f,P_4^f)$	$P^1=(0.7,0.75,0.8,0.82)$	$P^2=(0.8,0.85,0.9,0.95)$	$P^3=(0.75,0.85,0.9,0.95)$
«Company assets» $A_1^f=(A_{11}^f,A_{12}^f,A_{13}^f,A_{14}^f)$	$A_1^1=(0.6,0.65,0.7,0.75)$	$A_1^1=(0.65,0.7,0.75,0.85)$	$A_1^1=(0.7,0.75,0.8,0.85)$

Table 2

Confidence level of restrictions

Restriction	$B^1=(0,0,b_3^1,b_4^1)=$ $=(0,0,80,100)$	$B_1^2=(b^{21},b^{21},\infty,\infty)=$ $=(0.7,0.7,\infty,\infty)$	$B_2^2=(b^{22},b^{22},\infty,\infty)=$ $=(0.6,0.6,\infty,\infty)$	$B_3^2=(b^{23},b^{23},\infty,\infty)=$ $=(0.85,0.85,\infty,\infty)$
Confidence	$\gamma^1=0.8$	$\gamma_1^2=0.8$	$\gamma_2^2=0.8$	$\gamma_3^2=0.8$

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In accordance with the filtration procedure [1], a conclusion is drawn as to the conformity or non-compliance of the project with the requirements system.

As the results of calculations show, for given levels of reliability of the implementation of restrictions, the second project does not pass for further consideration (as a result of the «filtering» procedure). For projects 1 and 3, all restrictions are met, therefore the final choice according to the criterion «Economic efficiency – NPV» will be carried out between these projects. Since the selection of the project is carried out according to one criterion, then for the given projects let's calculate the characteristic:

$$Pos(A \in K) = \max_{y} \min(\mu_A(y),\ \mu_K(y)), \qquad (2)$$

which will be: for the first project $Pos(A^f \in K) = 1$ (Fig. 1) and for the third project (Fig. 2).

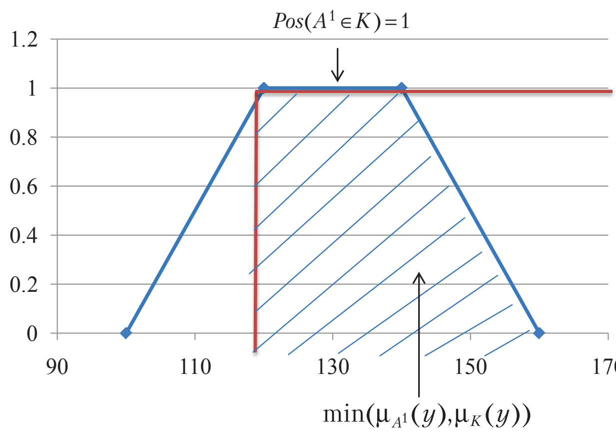

Fig. 1. Determination *Pos* of the fulfillment of the criterion condition for the first project

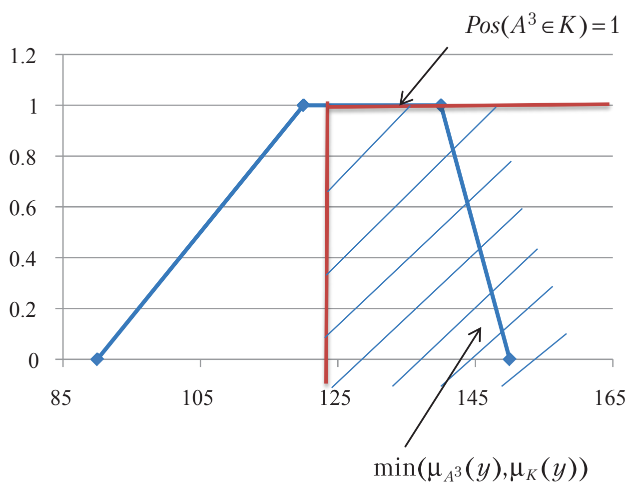

Fig. 2. Determination *Pos* of the fulfillment of the criterion condition for the third project

As it is possible to see, the possibilities of obtaining the necessary NPV are the same for these projects. Therefore, it is necessary to analyze which of the projects provides a larger NPV with a greater possibility (Fig. 3, 4). Fig. 3 shows that if the criterion is set as $K_1 = (k^{11}, k^{11}, \infty, \infty) = (140, 140, \infty, \infty)$, then $Pos(A^1 \in K) = 1$, for $K_1 = (k^{11}, k^{11}, \infty, \infty) = (150, 150, \infty, \infty)$, $Pos(A^1 \in K) = 0.5$.

Fig. 4 presents similar reasoning for the third project. As it is possible to see for $K_1 = (k^{11}, k^{11}, \infty, \infty) = (140, 140, \infty, \infty)$, $Pos(A^2 \in K) = 1$, but for $K_1 = (k^{11}, k^{11}, \infty, \infty) = (150, 150, \infty, \infty)$, $Pos(A^2 \in K) = 0$.

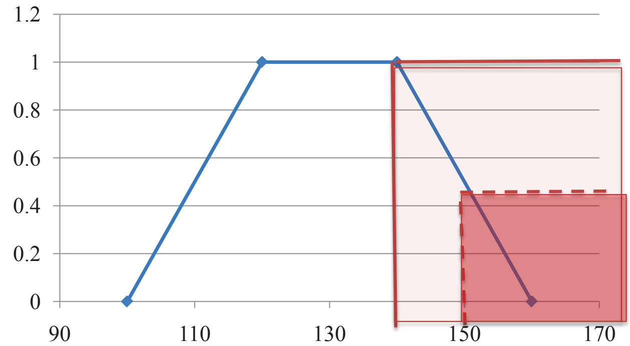

Fig. 3. Graphical analysis of the possibilities of obtaining different NPV values for the first project

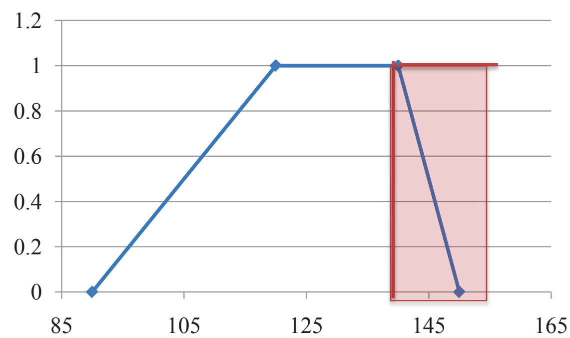

Fig. 4. Graphical analysis of the possibilities of obtaining different NPV values for the third project

Therefore, it can be argued that the first project provides a greater NPV value with a greater level of capability than the third project. Therefore, let's select the first project for implementation. In addition, it is possible to use the Chang method to obtain a numerical estimate for fuzzy numbers and obtain numerical estimates of the NPV criterion for the projects under consideration. There are several approaches to obtaining a numerical estimate based on an indistinct number, however, the Chang method is the simplest and does not require additional information. According to the Chang method, the following value is calculated for each trapezoidal fuzzy number $A = (a_1, a_2, a_3, a_4)$ [9]:

$$ch(A) = \frac{a_3^2 + a_3 a_4 + a_4^2 - a_1^2 - a_1 a_2 - a_2^2}{6}. \qquad (3)$$

For the first project $E_1^1 = (100, 120, 140, 160)$, so:

$$ch(E_1^1) = \\ = \frac{140^2 + 140 \cdot 160 + 160^2 - 100^2 - 100 \cdot 120 - 120^2}{6} = 5200.$$

For the third project $E_1^3 = (90, 120, 140, 150)$, so

$$ch(E_1^3) = \\ = \frac{140^2 + 140 \cdot 150 + 150^2 - 90^2 - 90 \cdot 120 - 120^2}{6} = 4966.$$

$$\max_f \{ch(X^f)\} = \max\{5200, 4966\} = 5200,$$

so, the best value of the Chang number for a given criterion for the first project. Thus, the reduction of the fuzzy estimate to a numerical one (the second variant of the definition of the best project for a given fuzzy criterion) gave a result similar to the approach outlined above.

Thus, the experimental studies of the project selection method proposed in [1] show its applicability and reliability of the obtained results. Graphical analysis of fuzzy estimates of the project allows to conduct reasoning about the acceptability of the project under various assumptions about the reliability of the constraints and the possibilities of obtaining the desired result.

7. SWOT analysis of research results

Strengths. The strength of the proposed approach to the selection of projects is the simplicity and the possibility of analyzing projects that have undergone initial selection in accordance with specified constraints. The type of used fuzzy numbers (trapezoid, which corresponds to accounting for pessimistic, optimistic and most probable estimates), the possibility of selecting one or more criteria – ensure the universality of the formalization of the procedure for selecting projects and its compliance with actual selection processes.

Weaknesses. The weak side of the proposed approach is the need for a «manual» calculation of the proposed algorithm.

Opportunities. The possibility of further development of the method is the elimination of the «weak side», that is, the use of specific software products. Practical use by enterprises of these developments will increase the effectiveness of development decisions and reduce risks, taking into account interval estimation of project implementation results.

Threats. The threat to this method is the difficulty in eliminating the «weak side», that is, the use of software products to simplify the practical implementation and automation of the proposed method.

The application of the proposed method does not require additional financial resources, which allows it to be used in decision-making processes for projects without involving additional resources, both financial and human.

8. Conclusions

1. As part of the pilot studies of the project selection method based on the possibility theory, the main stages of this method are characterized:

– formation of initial data on the «project map» in the form of trapezoidal fuzzy numbers, which corresponds to optimistic, pessimistic and most probable options for the implementation of projects;

– formation of a system of criteria and limitations, establishment of confidence levels;

– «filtering» projects through a system of restrictions;

– selection of the best project from the set, passed «filtration» on the basis of the given criterion, the possibility of using the system of criteria is characterized.

2. The characteristics of the projects under consideration and the requirements for them are interpreted in terms of the possibility theory. In accordance with the procedure of the method, a project is selected, accompanied by graphic interpretations of operations within the framework of fuzzy logic. The analysis of the influence on the choice of such characteristics used in the method as «reliability» and «possibility» is graphically demonstrated.

The obtained results substantiate the reliability and applicability of the method in practice.

In the process of experimental calculations, the best of the two criteria is selected from the three projects under consideration after the filtration procedure from the two projects.

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АНАЛИЗ ПРАКТИЧЕСКОГО ИСПОЛЬЗОВАНИЯ МЕТОДА ОТБОРА ПРОЕКТОВ НА БАЗЕ ТЕОРИИ ВОЗМОЖНОСТЕЙ

Выполнена практическая апробация метода отбора проектов на базе теории возможностей. Рассмотрены в терминах теории возможностей характеристики рассматриваемых проектов и требования к ним. Осуществлен отбор проекта, сопровождаемый графическими интерпретациями операций в рамках нечеткой логики. Графическим образом продемонстрирован анализ влияния на выбор проекта таких характеристик, как «достоверность» и «возможность».

Ключевые слова: метод отбора проектов, трапециевидные числа, функция принадлежности, теория возможностей, «фильтрация» проектов.

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