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Multicriterial Approach to Investment Projects' Estimation under Risk Conditions

Enfoque Multicriterial para la Estimación de Proyectos de Inversión bajo Condiciones de Riesgo

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Content

ABSTRACT:
Multi-Criteria Decision Making (MCDM) methods have evolved to accommodate various types of applications. Dozens of methods have been developed, with even small variations to existing methods causing the creation of new branches of research. This paper performs an original research of Multi-Criteria Decision Making methods in investment management, examines the advantages and disadvantages of the identified methods under risk environment, and explains how their common applications relate to the effectiveness of investment projects. The analysis of MCDM methods performed in this paper provides a clear guide for how MCDM methods should be used in investment project's analysis.
Keywords: multicriterial approach, risk management, Pareto set, investment project

RESUMEN:
Los métodos de toma de decisiones de criterios múltiples (MCDM) han evolucionado para adaptarse a varios tipos de aplicaciones. Se han desarrollado docenas de métodos, incluso con pequeñas variaciones de los métodos existentes. Este documento proporciona una investigación original de la Decisión Multi-Criteria en el campo de las estrategias de inversión. El análisis de los métodos MCDM realizados en este documento proporciona una guía clara sobre cómo los métodos MCDM deben usarse en el análisis del proyecto de inversión.
Palabras clave: enfoque multicriterial, gestión de riesgos, conjunto de Pareto, proyecto de inversión

1. Introduction

The most common problem of developing and introducing more advanced forms and methods of management into the broad practice is investment analysis. Important steps in the process of making economic decisions are 1) the creation of a indicators' system (including decision criteria) 2) analysis and prediction of the problem's development for the subsequent generation and selection of alternatives (Lukicheva, L.I. ,2016). The quality of the decisions made is essentially determined by the choice of the alternative.

The choice of the investment's direction directly depends on the effectiveness's evaluation of the analyzed alternatives. In the case of strategic decisions, this circumstance should be taken into account, since it is a question of spending a considerable amount of resources.

The multilateral nature of economic activity cannot be expressed by one one-dimensional index. Strengthening the tendency to more fully take into account the entire set of goals facing the economic organization, reflection in the analysis of real decision-making conditions, explains the growing interest in multidimensional methods of analysis and evaluation of economic decisions (Brigham, F. E., Ehrhardt, C. M., 2015).

All enterprises are more or less connected with investment activities. Decision-making on investment includes the need to take into account various complicating factors: the limited financial resources available for investment, the type of investment itself, and the possible losses that the enterprise may incur in the event the project is less efficient than it appears at the time it was drafted. Risk management allows increasing the validity of the project solution and reducing the likelihood of adopting an inefficient project.

The goal of this research is to implement multicriterial approach to investment projects' risk evaluation.

Authors submit research questions (RQ):

> RQ1: What are the benefits of implementing multicriterial approach into investment projects' evaluation?
>
> RQ2: What are the limitations of implementing multicriterial approach into investment projects' evaluation?

This research has a limitation: authors use sample model for improving or rejecting research questions.

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2. Theoretical Framework of Investment Project's Evaluation

We may find a large number of economical indicators, which are known well in business and they can allow managers to compare various alternatives to investing (Savchuk, V.P. , 2007). Methodical documents most often recommend the use of the following indicators: net present value (*NPV*), discounted payback period (*DPP*), internal rate of return (*IRR*) (Mazur, I.I. , 2014).

These indicators help decide whether to accept or reject a project or choose the best alternative from several options. However, they describe the effectiveness of the analyzed project from several different points of view. This leads to the necessity of constructing a multidimensional criterion.

Discussing the economic literature, we pay attention to both main methods of calculating the indicator "payback period":

1. The first approach takes into account the point of view of the capital's owner. The payback period is calculated as the period for which the owner receives a profit equal to the amount of invested capital. This suggests that this project provides at least the conditions of simple reproduction, taking into account the presence of a time factor.
2. An alternative method takes into account the view of the business manager, for which the size of the pure discounted income is important. In this case, the payback period is determined by the time of obtaining a net discounted income, which compensates for the amount invested in the project

capital (Seitz, N. E., Ellison, M., 1999).

Comparison of alternative projects based on these indicators can lead to different ordering of the analyzed options. This is all the more true, given the dynamics of various factors that affect the effectiveness of projects. The *NPV index* reflects a look at the effectiveness of the company's management. According to this, in our case, it is advisable to use the indicator of the payback period calculated on the basis of the received profit's measurement for the formation of a multidimensional criterion.

Based on the *IRR index,* it is also possible to obtain an ordering different from that obtained on the basis of the *NPV index* (Stoyanova, E.S., 2006; Syroezhin, I.M., 1980). The indicator of the internal rate of return is specific. He, in fact, measures the effectiveness of capital investments. This indicator allows to partially solve the problem of comparing investment projects with different amounts of capital investments and different terms of implementation. In other words, the requirement of the same amount of investment and / or the term of alternative projects is mandatory from a theoretical point of view. Typical methodological recommendations for calculating the effectiveness of investment projects solve this problem, simply preferring the indicator of *NPV*.

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3. Methodology.

The above considerations lead to the conclusion that it is necessary to use methods for evaluating the effectiveness of alternative investment projects that are based on a multi-criteria choice. Known methods of multicriteria choice are not brought to the methodical solutions that can solve the problem of choosing the optimal investment solution (Rua, B., 1976). The choice of an effective investment project includes a best combination's analysis of the values of disparate indicators characterizing the investment project. The need to evaluate alternative solutions from the point of view of several criteria in the task of choosing the direction of investment is complicated by the multiplicity of indicators, because they precise estimates, due to the complexity of the conditions for the implementation of projects, and therefore cannot be obtained.

Also we should recognize another serious problem, that investment projects are generally implemented in a risk environment. This means significant environmental uncertainty. Its changes are caused by a decrease or increase in cash flows generated during the implementation of the analyzed investment project. Because of this, it is possible that the goals set by the investor will not be reached, and the latter will incur losses.

The size of losses and their probability characterize the risk that is typical for each type of entrepreneurial activity. Without consideration of risk, the evaluation of the alternatives under consideration becomes unrealistic (Orlovsky, S.A., 1981; Parrino, R., Kidwell, D., Bates Th., 2014).

There are two mutually complementary types of project risks' analysis: quantitative and qualitative. Qualitative analysis determines the factors, scope and types of risk. Before the quantitative analysis, the task is to quantify the size of the identified risks and the damage from failure to achieve the project objectives.

The variety of risks of the investment project seriously complicates the tasks of qualitative analysis, including risk classification. Discussing economic literature we can obtain different approaches to solving this problem. In the analyzed case, it seems appropriate to classify the risks from the point of view of their origin (Khokhlov, N.V., 2011).

The calculation of economic efficiency in terms of risk involves identification of risk factors in classified areas, identification of risk situations, and the correlation of the risk situation with the consequences as the results of the investment project points' implementation (Rodionova, E.A., Epshtein, M.Z., Petukhov, L.V., 2013).

Risk factors are unplanned events that can occur and cause a deviation from the planned progress of the project. There is a dynamics of risk factors' values, which affects the effectiveness of the project. The combination of possible risk factors' values and consequences from them determine the situation of risk.

The stage of "quantitative risk analysis" includes the quantification of both individual risks and the risk of the entire project. At this stage, the possible damage (risk) is also determined. The most common methods of quantitative risk analysis include: statistical analysis, scenario building, expert assessments, analytical methods, and the use of decision trees and simulation modeling (Bukhvalov, A., 2011). Each of these methods has certain drawbacks (disadvantages). They can be compensated for using an integrated approach.

Modern methods of calculating the effectiveness of the investment project assume the use of a one-dimensional criterion. The risk situation is taken into account in them using the sensitivity assessment procedure. It consists in analyzing the changes in project results depending on the dynamics of risk factors. Different authors suggest a different approach. It is based on the use of the multicriteria selection method. The peculiarity of the proposed approach is the use of multi-criteria choice with an interval estimation of the project's riskiness.

4. Survey

In previous survey of authors the complex approach was proposed based on the calculation for each analyzed alternative of net discounted income, the discounted payback period, and the internal rate of return (Rodionova, E.A., Epshtein, M.Z., Petukhov, L.V., 2013). The peculiarity of this approach is also that it takes into account the uncertainty of the external environment. To do this, expert estimates of the likelihood of damage from the implementation of the project and the intervals of fluctuations of the above criteria for the effectiveness of the investment project are used.

Authors will continue the development of this approach and consider in more detail the accounting of the risk component of the multidimensional estimation. It is known that uncertainty presupposes the presence of factors under which the results of actions are not deterministic, and the degree of possible influence of these factors on the results is unknown (Vedernikov, Y.V., 2011). Authors will more closely consider the uncertainty factor and the possibility of the occurrence of damage. To do this, let us include in the expert opinion the forecast of the market situation in the future and the risk assessment in each of the possible situations. This approach allows us to include a generalized risk indicator, which can reflect, as components, various types of risk.

Based on the results of the expert survey, Authors estimate the ranges of values for all indicators taking into account the risk for alternative investment projects. Intervals are determined by experts both in absolute values of indicators, and in points (Rodionova, E.A., Epshtein, M.Z., Petukhov, L.V., 2013).

Let's estimate the effectiveness of alternative options and choose the most preferable one based on the built-in interval preference ratio (*IPR*). We use the notation introduced in survey "Scientific and methodical apparatus of vector preference…" (Vedernikov, Y.V., 2011).

Authors note, that $I=\{I_\alpha,\alpha=1...n\}$ is set of variants of investment projects,

$K_i(I_\alpha)=[A_i(I_\alpha);B_i(I_\alpha)]$ - criteria for assessing the effectiveness of each investment project in the interval form, $i=1...r, r-$ the total number of evaluation criteria, $A_i(I_\alpha)$ and $B_i(I_\alpha)$ - lower and upper bounds of the evaluation interval,

$K(I_\alpha)=\{K_1(I_\alpha),K_2(I_\alpha),...K_r(I_\alpha)\}=\{[A_1(I_\alpha);B_1(I_\alpha)],[A_2(I_\alpha);B_2(I_\alpha)],...[A_r(I_\alpha);B_r(I_\alpha)]\}$ - vector indicator of the each investment project's effectiveness. We introduce the notation *II* for the set of Pareto-optimal *IP* (*II* $\subset$ *I*) with the number of elements $\gamma \leq n$ satisfying the dominance condition $II_{m1} \succ II_{m2} \succ ...II_{m\gamma}, m_j=1...\gamma$. Now the problem is formulated as follows: to construct the Pareto tuple of considered variants of investment projects, whose elements satisfy one of the conditions

$$K_i(I_{\gamma_j})=\min[K_i(I_\alpha)], I_{\gamma_j}\in II \quad \text{or} \quad K_i(I_{\gamma_j})=\max[K_i(I_\alpha)], I_{\gamma_j}\in II .$$

Authors note that if the exponent is a scalar quantity, it can be represented as a degenerate interval with coincident ends $A_i(I_\alpha)=B_i(I_\alpha)$ (Orlovsky, S.A. (1981); Serguieva, A., 2014).

The ambiguity in the choice of criteria and the variety of factors are taken into account, because of the complexity of the assessing problem of the investment projects' effectiveness. It is necessary to assume that the decision-maker (usually project manager) does not have a clear opinion on the preferences to the analyzed alternatives. The representation of indicators by interval values and the qualitative difference of the measured quantities, which is expressed in the difference of the units of measurement, make it expedient to compare the variants based on the interval preference ratio (IPR) (Vedernikov, Y.V., 2011).

Let's mean m_i like the width of the estimates' interval for the *i-th* criterion. According to fuzzy methods (Orlovsky, S.A., 1981), the interval relation of preference R^u on the set I_α is the set of the Cartesian product $I_k x I_l, (k=1,...n, l=1,..n, k\neq l)$. For its characteristic, we keep the interval membership function $\mu^u K_i(I_k,I_l)$: $I_k x I_l \rightarrow [-1;1]$.

$$\mu^u K_i(I_k,I_l)=\frac{K_i(I_k)-K_i(I_l)}{m_i}=\frac{[A_i(I_k);B_i(I_k)]-[A_i(I_l);B_i(I_l)]}{m_i} \tag{1}$$

Each value of the membership function $\mu^u K_i(I_k,I_l)$ estimates the degree of gain and damage in recognizing variant I_k as the dominant variant I_l by the criterion K_i.

The degree of dominance of the alternative I_k over the alternative I_l by the interval criterion K_i is represented by the membership function $\mu_D{}^u K_i(I_k,P_l)$, which determines the ratio of strict interval preference

$$\mu_D{}^u K_i(I_k,I_l)=\mu^u K_i(I_k,I_l)-\mu^u K_i(I_l,I_k) \tag{2}$$

For comparison, it is important to establish the fact that the alternative I_k is not undermined over the *II* alternative, which is determined by the membership function

$$\mu_{ND}K_i(I_k,I_l)=\begin{cases} 1, & if\ \mu_D{}^u K_i(I_k,I_l)<0, \\ 1-\mu_D{}^u K_i(I_k,I_l), & if\ \mu_D{}^u K_i(I_k,I_l)\geq 0 \end{cases} \tag{3}$$

Then, for the *i-th* interval criterion, the proximity of the alternative I_k to the Pareto-optimal variant is characterized by the value of the membership function for the set of non-dominated alternatives (Orlovsky, S.A., 1981; Vedernikov, Y.V., 2011).

$$\mu_D^* K_i(I_k) = \min \mu_{ND} K_i(I_k, I_l) \tag{4}$$

Authors investigate the problem of choosing investment projects on the basis of the above criteria: *NPV, DPP, IRR* and multidimensional risk of investment project. Authors analyze the limitations in the use of the selected criteria.

NPV depends on the amount of cash flows at specific times and the discount rate *r* (Bukhvalov, A., 2011):

$$NPV = \frac{C_1}{(1+r)^{t1}} + \frac{C_2}{(1+r)^{t2}} + \ldots + \frac{C_n}{(1+r)^{tn}} \tag{5}$$

As a discount rate, a risk-free interest rate or a rate of interest for projects with the same degree of risk, or the sectoral coefficient of capital investments' efficiency, are generally used. By this criterion, a project with a maximum value with the same value of *r* is selected. Net present value depends heavily on the discount rate. An ungrounded forecast of the discount rate leads to an incorrect management decision: a good project can be rejected, and a bad one can be accepted. Due to the specification of *NPV* interval values, this problem goes to the background. The optimal condition for the *NPV* criterion is its maximum.

The discounted payback period is expressed in a time interval. The optimal option for this criterion corresponds to its minimum. The internal rate of return is expressed in percentages and is given by an interval value. By this criterion, a project corresponding to the maximum value of this criterion is selected.

5. Results

5.1. Data implication and results

Risk assessment is reflected by interval values in points. Assuming that the interest rate r is a random variable for which the probability of a random event can be found, $NPV(r, t) > 0$, $P(NPV(r, t) > 0) = P(r < IRR) = F(IRR)$. Here $F(x) = P(r < x)$ is the distribution function of *r*, *IRR* is the internal rate of return, which is found as a solution to the equation $NPV(t, r) = 0$. For different *r*, it is possible to establish the probabilities that the project will not pay off at time *t,* and then construct score scores using the valuation procedure. Let make the riskiness evaluation of the project according to the above methodology for the three possible predictable market conditions, and experts estimated the likelihood of implementing each of them. Authors note that the criterion for assessing the risk of investment project requires choosing the best option from the condition of minimum value of the criterion.

On the basis of known theoretical representations, the values of *mi* are chosen as the maximum permissible for the considered criteria. The initial data required for the calculations for the investment projects analysis are presented in Table 1.

Table 1
Data implication for variety of projects

Projects ---------------------Indicators	I_1	I_2	I_3	m_i
$K_1(I_\alpha)$- *NPV*(USD)	[50;60]	[70;120]	[80;100]	200
$K_2(I_\alpha)$-*DPP*(annual)	[3;8]	[4;6]	[5;9]	10
$K_3(I_\alpha)$-*IRR*(%)	[16;17]	[10;20]	[14;18]	30
$K_4(I_\alpha)$-risk evaluation (points)-pessimistic forecast, $p_4 = 0.25$	[6;8]	[3;9]	[5;9]	10
$K_5(I_\alpha)$-risk evaluation (points)-realistic forecast, $p_5 = 0.5$	[4.5;7]	[5;8.5]	[4;7]	10
$K_6(I_\alpha)$-risk evaluation (points)-optimistic forecast, $p_6 = 0.25$	[4;5]	[4;6]	[3;5.5]	10

Using formula (1), we find the values of the membership function μиKi(Ik,Il) for each pair of variants for each criterion, and authors will compute the estimated matrices of them. Authors write in more detail the expression (1):

$$\mu^u K_i(I_k,I_l)=\frac{\left[\min\{A_i(I_k)-A_i(I_l);B_i(I_k)-B_i(I_l)\};\max\{A_i(I_k)-A_i(I_l);B_i(I_k)-B_i(I_l)\}\right]}{m_i}$$

And denote by

$$C^{kl}{}_i=\frac{\min\{A_i(I_k)-A_i(I_l);B_i(I_k)-B_i(I_l)\}}{m_i},\quad D^{kl}{}_i=\frac{\max\{A_i(I_k)-A_i(I_l);B_i(I_k)-B_i(I_l)\}}{m_i}$$

Then

$$\mu^u K_i(I_k,I_l)=[C_i^{kl};D^{kl}{}_i] \tag{6}$$

Then the interval membership function for the I_l, I_k takes the form

$$\mu^u K_i(I_l,I_k)=[-D_i^{kl};-C^{kl}{}_i] \tag{7}$$

Hence, if relation $\left|C_i^{kl}\right|=D^{kl}{}_i$ is existed, then the values $\mu^u K_i(I_l,I_k)$ and $\mu^u K_i(I_k,I_l)$ coincide.

Using formula (2), authors reflect the preference intensity for each pair of variants for each criterion through the values of the membership function $\mu_D{}^u K_i(I_k,I_l)$ and include them in the estimated matrices. On the basis of expressions (6) and (7), authors simplify the calculations.

Authors have $\mu_D{}^u K_i(I_k,I_l)=[C_i^{kl};D^{kl}{}_i]-[-D_i^{kl};-C^{kl}{}_i]=[C_i^{kl}+D^{kl}{}_i;C_i^{kl}+D^{kl}{}_i]$.

Then authors reach

$\mu_D{}^u K_1(I_\alpha)=\begin{pmatrix} - & -0.4 & -0.35 \\ 0.4 & - & 0.05 \\ 0.35 & -0.05 & - \end{pmatrix}$, $\mu_D{}^u K_2(I_\alpha)=\begin{pmatrix} - & 0.1 & -0.3 \\ -0.1 & - & -0.4 \\ 0.3 & 0.4 & - \end{pmatrix}$

$\mu_D{}^u K_3(I_\alpha)=\begin{pmatrix} - & 0.1 & 0.03 \\ -0.1 & - & 0.06 \\ -0.03 & -0.06 & - \end{pmatrix}$, $\mu_D{}^u K_4(I_\alpha)=\begin{pmatrix} - & 0.2 & 0 \\ -0.2 & - & -0.2 \\ 0 & 0.2 & - \end{pmatrix}$

$\mu_D{}^u K_5(I_\alpha)=\begin{pmatrix} - & -0.2 & 0.05 \\ 0.2 & - & 0.25 \\ -0.05 & -0.25 & - \end{pmatrix}$, $\mu_D{}^u K_6(I_\alpha)=\begin{pmatrix} - & -0.1 & 0.05 \\ 0.1 & - & 0.25 \\ -0.05 & -0.25 & - \end{pmatrix}$

Applying the formulas (3) and (4), authors find the values of the membership function $\mu_{ND}{}^u K_i(I_k,I_l)$ for each pair of variants for each criterion and compile the membership function values for the set of non-dominated variants $\mu_D^* K_i(I_k)$:

$\mu_D^* K_1(I_k)$={0.6, 1,0.95}, $\mu_D^* K_2(I_k)$={0.9,1,0.6},

$\mu_D^* K_3(I_k)$={1 ,0.9 ,0.93}, $\mu_D^* K_4(I_k)$={1, 0.8, 1},

$\mu_D^* K_5(I_k)$={0.9, 0.75, 1}, $\mu_D^* K_4(I_k)$={0.95, 0.75, 1}

Based on the analysis of the values $\mu_D^* K_i(I_k)$, it can be concluded that option I_2 is the best by the criteria $K_1(I_\alpha)$ and $K_2(I_\alpha)$, option I_1 is the best by criterion $K_3(I_\alpha)$ and by the risk criterion in case of a pessimistic forecast, and option I_3 is the best in risky criterion on the considered set of investment projects' variants.

To determine the preference relation on the set of investment project's variants, authors use the definition of the vector preference, which is presented in other surveys (Orlovsky, S.A., 1981; Vedernikov, Y.V., 2011). The membership functions $\mu_D^* K_i(I_k)$ characterize the degree of proximity of the variant I_k to the Pareto-optimal variant of the investment project by the criterion K_i, so authors use them instead of the traditional coefficients of the importance of the criteria. Let compare the variants I_k and I_l in pairs, analyzing the values $\mu_D^* K_i(I_k)$ and introducing the subsets I_{kl}^+, I_{kl}^-, $I_{kl}^=$ of the best, worst and equal values $\mu_D^* K_i(I_k)$ and $\mu_D^* K_i(I_l)$ *(i = 1..4; k, l = 1, .. 3, k ≠ l)* of these variants. Define the elements of the evaluation matrix $\left\| C_{kl}^\mu \right\|$ based on the conditions (Table 2) (Vedernikov, Y.V., 2011):

Table 2
Elements' values of the evaluation matrix

I_{kl}^+	I_{kl}^-	$I_{kl}^=$	C_{kl}^μ	C_{lk}^μ	Notes
Ø	Ø	{1..3}	1	1	-
{1..3}	Ø	Ø	N_2	0	-
Ø	{1..3}	Ø	0	N_2	-
≠Ø	Ø	≠0	N_3	0	$1 \ll N_3 < N_2$
Ø	≠Ø	≠0	0	N_3	-
≠Ø	≠Ø	$\left\|S_{kl}^=\right\| \geq 0$	Formula (8)	$C_{lk}^\mu = 1/C_{kl}^\mu$	-

$$C_{kl}^{\mu} = (\sum_{i=1}^{3} \mu_D^* K_i(I_k))(\sum_{i=1}^{3} \mu_D^* K_i(I_l))^{-1} \tag{8}$$

When drawing up a matrix of assessments based on the risk criterion, authors take into account the possibility of the onset of various risk conditions as weighted estimates of matrix elements

$$C_{kl}^{\mu} = (\sum_{i=1}^{6} a_i \mu_D^* K_i(I_k))(\sum_{i=1}^{6} a_i \mu_D^* K_i(I_l))^{-1}$$

$$a_i = \begin{cases} 1, & i = 1,2,3 \\ p_i, & i = 4,5,6 \end{cases}$$

Then authors get the following matrix of preferences

$$\left\| C_{kl}^{\mu} \right\| = \begin{pmatrix} - & 0.66 & 5.01 \\ 1.51 & - & 0.94 \\ 0.19 & 1.05 & - \end{pmatrix}$$

Using the technique proposed in [9] on the basis of the theoretical scheme [7], authors introduce the indicators: G_l^{μ} and H_l^{μ} - the number of elements of the *l-th* column of the matrix $\left\| C_{kl}^{\mu} \right\|$, the value of which is less than one, but greater than zero and greater than one, respectively, and an indicator $C_{kl\max}^{\mu}$ equal to the maximum value element of the *l-th* column. Then H_l^{μ} will show the number of variants of investment project dominating the *l-th*. G_l^{μ} will indicate how many variants of the investment project dominates the *l-th*, and $C_{kl\max}^{\mu}$ reflects the maximum degree of dominance of the *k-th* version of the investment project over the *l-th*.

Imagine the indicators in the form of a matrix (Table 3).

Table 3
Matrix of indicators

Investment projects, variants Indicators	I_1	I_2	I_3
G_l^{μ}	1	1	1
H_l^{μ}	1	1	1
$C_{kl\max}^{\mu}$	1.51	1.05	5.01

Analysis of Table 3 shows that the best alternative to an investment project with a minimum value $C_{kl\max}^{\mu}$ is option I_2. Therefore, the 2nd version of the investment project is included in the Pareto tuple and excluded from the further analysis, by deleting the corresponding row and the column of the preference matrix.

The remaining options are analyzed using the new matrix of indicators, using the same scheme of reasoning.

Finally, the tuple of Pareto preferences will be written like this:

$II = \{I_2, I_1, I_3\}$. Therefore, the best alternative for the vector inhomogeneous efficiency index $K(I_\alpha)=\{K_1(I_\alpha), K_2(I_\alpha), K_3(I_\alpha), K_4(I_\alpha), K_5(I_\alpha), K_6(I_\alpha)\}$ should be recognized as the second variant . In the Pareto tuple of the considered variants, preference was expressed for the criteria characterizing the net discounted income and discounting for the calculation of the payback period in the vector efficiency index.

5.2. Discussion

The application of a multi-criteria approach to the evaluation of investment projects has advantages and disadvantages. Advantages include such factors as flexibility in use, variability, the use of multiple criteria, the possibility of comparing and evaluating the whole pool of projects in one period.

To the disadvantages of using a multi-criteria approach can be attributed: the instability of the external environment and caution in the use of risk factors that affect the attractiveness of the investment project.

6. Conclusions

The described algorithm for selecting an investment project is adapted to take into account the situation of risk. In addition to taking into account the diversity of economic interests inherent in the economic system, it makes it possible to reflect the uncertainty of the forecasted states of the system under study. This is achieved by describing risk situations and introducing a multicomponent representation of the risk component as one of the decision criteria.

This approach enhances the possibility of applying the multicriteria selection method for the real conditions of economic activity. It reflects the specifics of the process of adopting a complex professional managerial decision in the economic system to the greatest extent. This algorithm for choosing an investment project can be recommended for making long-term strategic decisions in a risk situation.

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