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CONCERNING SOME ASPECTS OF CONSIDERATION OF RISK COMPONENT IN INVESTMENT PROJECT EFFICIENCY EVALUATION

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The research paper proposes a scheme of investment decision making in the company that provides for step-by-step investment project efficiency evaluation (including step-by-step consideration of the risk component), and takes into account the project's impact on corporate image and strategic development. The authors make a brief analysis of the most popular methods of risk assessment in investment project efficiency evaluation. The research paper introduces a model of ranking investment projects under study by their implementation preference level. To estimate implementation preference levels, scenario approach is used and an appropriate antagonistic game is solved, which simulates investment decision making in an uncertain and conflict environment and under economic risk caused by this environment.
Key words: investment project, efficiency evaluation, risk, ranking, implementation preference level, scenario approach, antagonistic game, uncertainty, conflict environment.

INTRODUCTION

In practice, the decision-maker (DM) always faces a set of alternatives when making a decision about implementation of a specific investment project (IP). In view of this, particular importance is attributed to methods and models aimed at selecting the best IP among its alternatives.

At the same time, it is hardly possible to make a sound investment decision without taking into account the risk component. According to Grabenko O.V., investment risk minimization is an indispensable condition of corporate financial sustainability and solvency [1, p. 107].

Thereby, it is essential to take into consideration the risk component when estimating IP efficiency and making investment decisions. The issue was considered by Bliumin S.L. [2], Vitlinsky V.V. [3; 4], Gracheva M.V. [5], Egorov P.V. [6], Laktionova A.A. [7], Livshits V.N. [8], Lysiuk A.P. [9], Matviychuk A.V. [10], Shcherbak A.V. [11], etc.

In spite of a set of publications devoted to the issue under study, at present there is no common opinion concerning the best method of risk assessment when making investment decisions in the company.

The research paper aims at developing a scheme of investment decision making in the real sector of economy as well as the game-theory method of consideration of the risk component.

With this aim in mind, the authors:

1. Propose an IP efficiency evaluation scheme, which provides for step-by-step consideration of the risk component.
2. Make a brief analysis of methods for consideration of the risk component when making investment decisions in the real sector of economy.

3. Design a model of ranking investment projects under study by their implementation preference level.

1. INVESTMENT PROJECT EFFICIENCY EVALUATION SCHEME

IP evaluation is a cost-based operation, involving both material costs and time consumption; therefore in investment decision making it is necessary to focus on step-by-step evaluation in order to significantly reduce all kinds of costs related to the pre-investment phase of the project life cycle and to speed up the process of efficient projects implementation.

We have designed an IP efficiency evaluation scheme (Fig. 1), which includes three levels of evaluation: **1.** IP preliminary estimate; **2.** IP deterministic evaluation (a more accurate evaluation of IP without taking into account risk exposure factor); **3.** Final decision making (selection of a project for implementation, taking into consideration risk exposure factor as well as IP's impact on corporate image and strategic development).

Let us briefly describe the process of investment decision making according to the given scheme. The ***zero stage of decision making*** is the ***formation of project ideas***. At this stage, project ideas are estimated according to their correspondence with DM's interests. In case a project idea corresponds with DM's preferences, it passes to the first level of decision making process — the stage of IP preliminary estimate; otherwise the idea is rejected.

The ***first stage of decision making*** includes preliminary cash flow forecast for the projects under study, which usually does not require heavy time and financial costs. Then DM calculates ***NV*** (net value) and ***PP*** (payback period), and makes qualitative evaluation of the projects' risk level and impact on corporate image and strategic development.

A project passes to the next (second) stage of decision making process provided it meets a number of conditions: its net value is positive ($NV > 0$); its payback period corresponds with DM's preferences ($PP \le PP_{preferable}$, where $PP_{preferable}$ — threshold value of payback period set by DM (investor); anticipated risk level of IP is allowable to DM; the project will have a positive (or neutral) influence on corporate image and strategic development. In case a project does not meet even one of the above conditions, it shall be rejected at this stage of investment decision making.

For the projects that have passed to the ***second stage*** of the given scheme (***IP deterministic evaluation***) we forecast (with more details and accuracy) cash flow and define discount rate. These data constitute the basis of calculation of dynamic index of IP efficiency evaluation (for instance, net present value, ***NPV***) or their total.

It should be stressed that in research papers and management practice there is no official choice of one priority index for IP efficiency evaluation. Some researchers (for example, [8]) adheres to the opinion that it is necessary to apply separate indices of IP efficiency evaluation, others – integral/composite (which are formed based on a number of criteria) indices (for instance, [12]).

In modern business practice, in the process of IP substantiation, DMs most commonly apply ***discounted indices*** of IP efficiency evaluation, which consider the behavior of cash assets in time, and are also based on calculation of the project's cash flow: net present value (***NPV***), profitability index (***PI***), internal rate of return (***IRR***) and discounted payback period (***DPP***). The monograph [8, p. 285-286] considers the algorithm of calculation of the above indices of IP efficiency evaluation for ***unsteady market economy***.

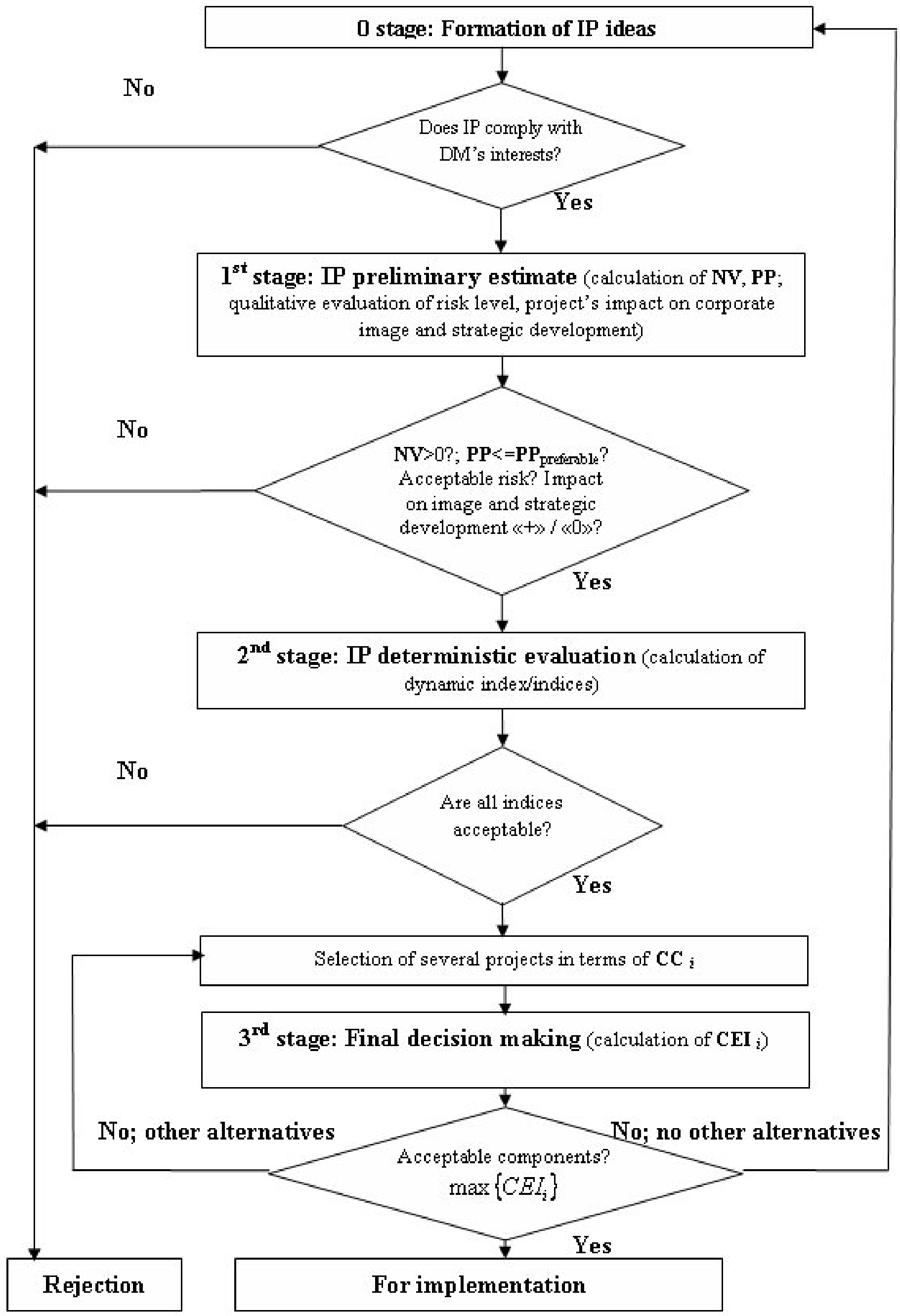

Fig. 1. Scheme of IP efficiency evaluation and investment decision making.

However, not all researchers consider it necessary to use the above discounted indices of IP efficiency evaluation as the basis of investment decision making. A number of researchers propose their own alternative indices. The monograph [8, p. 296-297] suggests new indices of IP efficiency evaluation, the calculation of which applies ***compounding*** operation (real net future value (***RNFV***), real internal rate of return (***RIRR***), real profitability index (***RPI***) and real payback period (***RPP***)).

The choice of priority index for IP efficiency evaluation (which enables to assess how the project succeeds commercially (financially) in the short term (planning horizon is IP calculation period); and which will be further referred to as ***commercial component***, CC_i) is a rather complicated and debatable issue, since each index has its own advantages and disadvantages. Most probably, in practice the choice of the most appropriate index (or their total) will depend on the company's policy of IP efficiency evaluation and will be defined by specific features of the project under study.

Having calculated ***commercial component***, DM checks its acceptability (if ***NPV*** is selected as ***commercial component***, it is necessary to make sure this index is not negative). In case it is positive, IP can be evaluated further; otherwise the project is rejected.

Then among successful projects DM chooses several IPs with the best values of ***commercial component*** to participate in final investment decision making.

The ***third stage of decision making*** includes additional research on how the risk component influences IP efficiency and what impact the project will have on corporate image and strategic development. Having formed the basis of estimate at this stage, DM calculates CEI_i for each alternative IP. CEI_i consists of three components: 1. ***commercial*** one, which already includes the risk component at this stage of investment decision making; 2. ***strategic*** one, which estimates how the project influences corporate strategic development; 3. ***reputation*** one, which characterizes a probable change in corporate reputation as a result of project implementation.

After the necessary calculations have been made, DM analyses the values of the obtained components of CEI_i in three directions: 1. Analyze the value of commercial component, which already takes into account risk exposure factor at this stage; the index should be acceptable; otherwise the project is rejected; 2. Assess how the project influences corporate image (if, according to the research findings, IP implementation causes negative corporate image, IP should be rejected); 3. Assess the project's probable impact on corporate strategic development (if the research findings show that project implementation has a negative impact on corporate future development, the project should be rejected).

If the above analysis results in acceptable projects, for implementation DM should recommend the project with the best CEI_i. In case all projects are unacceptable (do not go through the three criteria analysis), DM should check for IP with good results at the second stage of decision making, but not selected for further analysis. Provided that such projects exist, the latter should be tried at the third stage of decision making process. In case there are no such projects, DM returns to the zero stage of decision making — the ***formation of project ideas***, and the process is restarted.

As a result of the scheme of decision making, DM will either select the most acceptable IP or will prove that there is no such project at the moment and new ideas are required.

2. BRIEF ANALYSIS OF METHODS OF RISK COMPONENT CONSIDERATION IN INVESTMENT DECISION MAKING IN THE COMPANY

IP implementation is usually associated with risk. According to Shcherbak A.V., investment decisions made by the company are not grounded and efficient without detection of investment risks at each stage and during investment process and their consideration when calculating IP efficiency and making investment choice [11, p. 222].

Research papers give different definitions of risk. In our opinion, the most accurate one is that presented in [4, p. 56]: “Risk is an economic category that reflects characteristics of perception by parties, who are involved in economic activity, of objectively existing uncertainty and conflict environment inherent to the processes of definition of objectives, management, decision making and evaluation, which are burdened with probable hazards and loss of opportunities.”

The research paper [6, p. 8] singles out conditions of investment risk existence as follows: the necessity of choice; material liability for the decision; probability of a negative outcome; irreversibility of the decision.

According to [3, p. 182-183], examination of IP risks involves three technical approaches: 1. analysis without consideration of the project’s interrelation with other assets of the company; 2. analysis in the frame of risk of existing assets and the project’s impact on the company’s risk as a whole; 3. analysis in the frame of market risk and opportunities of formation of investment portfolios by separate investors.

Researchers distinguish between qualitative and quantitative risk analysis. The qualitative analysis includes: detection of probable project risks as well as definition of reasons and factors influencing their level; description and cost estimate of probable damage; design of a set of anti-risk measures [5, p. 74]. The quantitative analysis is related to numerical expression of risks as well as definition of IP risk value as a whole [5, p. 78].

The monograph [4, p. 157-180] makes a detailed analysis of quantitative indices of risk level in absolute figures and in relative terms, and emphasizes that quantitative risk evaluation is multidimensional quantity, and its components should be formed subject to the research objectives [4, p. 183].

Laktionova A.A. divides all methods of investment project risk evaluation into two groups: 1. related to direct evaluation of risk as a criterion; 2. related to consideration of risk in the resulting efficiency index (consideration in discount rate or consideration in IP cash flow) [7, p. 46].

Table 1 displays advantages and disadvantages of the basic methods for consideration of the risk component in investment decision making: expert evaluation method; statistical approach; costs expediency analysis; decision tree method; simulation modeling; game-theory approach; analog approach; threshold level analysis; method of discount rate with correction for risk; sensitivity analysis; scenario analysis.

Table 1

Advantages and disadvantages of risk assessment methods in investment decision making in the real sector of economy

Advantages	Disadvantages
1. Expert evaluation method	
Application in case of unavailability of required information.	Subjective evaluation; it is difficult to find independent experts; the field under analysis is narrow; no possibility to adjust the model to real data.
2. Statistical approach	
The obtained results are highly consistent; no influence of subjective judgments.	Availability of sufficient amount of statistical data; no possibility to analyze risk sources.
3. Costs expediency analysis	
It is possible to find ways of risk reduction.	Neglect of numerous risk components.
4. Decision tree method	
Clearness; simplicity; consistency of carrying out.	Heavy time consumption by research process; probability of underestimating a certain element of the system.
5. Simulation modeling	
High accuracy of the results; consideration of interrelation among variables; possibility to obtain an unlimited set of random scenarios.	Complexity of carrying out.
6. Game-theory approach	
Developed analysis procedure; choice of optimum alternative among revealed ones.	No definition of risk factors.
7. Analog approach	
The possibility to estimate risk level without available data base.	High probability of mistake; neglect of the factor that any activity develops.
8. Threshold method analysis	
	Necessity to comply with a number of restrictions.
9. Method of discount rate with correction for risk	
User friendly.	Approximate approach; it is difficult to define correction for risk.
10. Sensitivity analysis	
Objectivity; theoretic transparency; user friendliness; clearness.	Underestimate of probable connections between separate factors.
11. Scenario analysis	
Simultaneous change of several risk factors; divergence of parameters is calculated with due account for their correlation; applicable for analysis and planning of nonstandard situations, definition of conditions for emergence of favorable and unfavorable situations; contribution to high flexibility in decision making.	It is difficult to build IP model and define connections among variables; it is necessary to make a substantial qualitative study of IP model; indefinite borders of scenarios; effect of a limited number of probable combinations of variables.

Source: based on the materials as follows [5, p. 86-89, 100; 9, p. 24; 10, p. 40; 14, p. 418; 15, p. 41; 16, p. 17; 17, p. 57; 18, p. 6; 19, p. 56; 20, p. 609-611].

It should be stressed that modern science has no common opinion on which of the above methods is the most preferable one, when taking into account the risk component in real investments. Thus, for instance, in spite of disadvantages of expert evaluation method, in practice there could be situations when an expert will be the only source of required information [13, p. 32]. The research paper [2, p. 15] says that "if an expert is unbiased and highly professional, his/her evaluations are close to objectivity."

Matviychuk A.V. regards statistical approach as the most objective method of quantitative evaluation of risk level [10, p. 40]. The essence of this method is in the possibility, in the presence of sufficient information on parameters of functioning of the system under analysis in the past, to assess risk level by the theory of probability [10, p. 39].

The research paper [19, p. 63] notes that application of scenario approach enables companies to reduce risks of large-scale investments and to increase the quality of strategic decisions. Zavadsky I. regards scenario approach as "one of the most efficient methods of decision making…" [17, p. 57].

According to Lysiuk A.P., the method of discount rate with correction for risk [9, p. 24] is the most preferable and user friendly one. We shall give the research paper [21] as an example of application of fuzzy sets when estimating risk in real investments.

In our opinion, the choice of a method for consideration of the risk component in investment decision making is subject to a specific practical situation.

3. GAME-THEORY MODEL OF RANKING INVESTMENT PROJECTS UNDER STUDY BY THEIR IMPLEMENTATION PREFERENCE LEVEL

When making a decision on investment of IPs under study, for analysis and evaluation of examined projects one should apply both individual and portfolio approaches (on the strength of all projects under study). Individual analysis should be complex (involving many efficiency indices) and based on qualitative and quantitative analysis of statistical information.

Thus, IP efficiency evaluation is defined by a set of indices. The project efficiency evaluation system is based on the hierarchical system of calculation of these indices. The system should take into account the dynamics of financial flow and the dynamics of corporate reputation emerging during project implementation, as well as inflation, uncertainty, conflict environment and economic risk caused by them. Making a decision concerning IP requires new methods and models to select the most preferable projects for implementation among all IPs under study.

We shall interpret a set of the most preferable projects for implementation as a finite fuzzy set $\widetilde{\boldsymbol{I}} = \{(\mu_1/1);...;(\mu_i/i);...;(\mu_k/k)\}$, where μ_i — grade of membership of IP i to fuzzy set $\widetilde{\boldsymbol{I}}$, $i = \overline{1, k}$. The set $\widetilde{\boldsymbol{I}}$ is a fuzzy subset of universal set $\boldsymbol{I} = \{1;...;i;...;k\}$ of all projects under study. In this case, universal set $\boldsymbol{I}$ is a usual (not fuzzy) finite set, and the main task of DM is to correctly evaluate project implementation preference levels, i.e. values of grade of membership μ_i of each IP to fuzzy set $\widetilde{\boldsymbol{I}}$, $i = \overline{1, k}$. We recommend solving this problem by means of scenario approach, in so doing one can in particular apply games theory.

In detail, investment decision making under the conditions of uncertainty, conflict environment and economic risk can be characterized by a game $\langle \boldsymbol{I}, \boldsymbol{J}, \mu \rangle$, where $\boldsymbol{I} = \{1;...;i;...;k\}$ — set of all IPs under study, $\boldsymbol{J} = \{1;...;j;...;n\}$ — set of all scenarios, $\mu = \mu_{k \times n} = (\mu_{ij})$ — evaluation functional, i.e. payoff matrix, μ_{ij} — value of grade of membership of project i to fuzzy set $\widetilde{\boldsymbol{I}}$ in conditions of scenario j, $i = \overline{1,k}$, $j = \overline{1,n}$. Generally speaking, this game represents a statistical game, i.e. game with "nature". However, in terms of the model of ranking IPs under study by their implementation preference levels, this game can be interpreted as an antagonistic game. We refer antagonistic game (AG) to an end two-player zero-sum game. Moreover, in that case, AG is not a situation model of investment decision making, and is only used as a searching tool for evaluation of implementation preference levels of projects under study. Thus, in this context, we shall speak of combined use of statistical and antagonistic games.

The model of ranking IPs under study by their implementation preference levels includes the following steps.

Step 1. The investor forms a set $\boldsymbol{I} = \{1;...;i;...;k\}$ of all projects under study.

Step 2. The investor forms a set $\boldsymbol{J} = \{1;...;j;...;n\}$ of all probable scenarios.

Step 3. The investor evaluates efficiency of each project in conditions of each scenario based, for instance, on the values of CEI_i calculated for each IP.

Step 4. The investor values μ_{ij} of grade of membership of IP i to fuzzy set $\widetilde{\boldsymbol{I}}$ of the most preferable projects for implementation in conditions of scenario j. Concrete values of elements μ_{ij} are defined by DM based on each project's efficiency evaluation carried out at the previous stage.

Step 5. The investor solves AG set by payoff matrix $\mu = \mu_{k \times n} = (\mu_{ij})$. For definiteness, we shall consider that the game has no saddle point; herewith, vector $\mathbf{p}^* = (p_1^*;...;p_i^*;...;p_k^*)$ characterizes optimal mixed strategy of the first player.

Step 6. The investor calculates $C = 1 \big/ \max\limits_i p_i^*$, where p_i^* — component of optimal strategy of the first player, $i = \overline{1,k}$, and values of grade of membership of project i to fuzzy set $\widetilde{\boldsymbol{I}}$ of the most preferable projects for implementation by formula $\mu_i^* = C \cdot p_i^*$, $i = \overline{1,k}$.

Application of the model of ranking IPs under study by their implementation preference level has a number of specific features. Firstly, if AG has no saddle point, i.e. $\alpha < \beta$, where $\alpha = \max\limits_i \alpha_i$ — lower pure value, $\beta = \min\limits_j \beta_j$ — upper pure value, $\alpha_i = \min\limits_j \mu_{ij}$, $i = \overline{1,k}$, $\beta_j = \max\limits_i \mu_{ij}$, $j = \overline{1,n}$, then in the formula as values of p_i^* one should use components of optimal mixed strategy $\mathbf{p}^* = (p_1^*;...;p_i^*;...;p_k^*)$ of the first player.

Secondly, if AG has a saddle point, i.e. the game's pure values coincide $\alpha = \beta$, then to define the values of p_i^* one can use domination (in a broad sense) of pure strategies of the first player. For example, let the first player has no pure strategy, strictly dominating all his/her other pure strategies, and his/her pure strategy l is his/her maximin strategy, i.e. $\alpha_l = \alpha = \beta$. Then $p_l^* = 1$, herewith the values of all other components of vector $\mathbf{p}^* = \left(p_1^*;...; p_i^*;...; p_k^*\right)$ should be calculated by solving AG set by matrix $\mu' = \mu'_{(k-1)\times n}$, derived from matrix μ by striking out a row l.

Thirdly, it is true that $C \geq 1$, and the value of multiplier C is sorted out in such a way to fulfill equation $\max_i \mu_i^* = 1$; herewith, if $\max_i p_i^* = 1$, then $C = 1$.

Fourthly, for final choice of the most preferable projects for implementation, DM should define minimum permissible preference level C^* (for instance, $C^* = 0.25$ or $C^* = 0.75$); herewith, IP i should be implemented if and only if $\mu_i \geq C^*$ is true for evaluation of its preference level.

Fifthly, the model of ranking IPs under study by their implementation preference level has a number of advantages (for example, the possibility of combining individual analysis for each individually taken project with portfolio approach allowing for comparative analysis of all projects), and a number of disadvantages (for instance, excessive caution during evaluation of project preference level). The model of ranking IPs under study by their implementation preference level should be first of all applied when DM considers that s/he has no right to risk, for example, in a crisis or pre-crisis environment.

Finally, if DM has succeeded in defining the precise true values of all elements of payoff matrix $\mu = \mu_{k\times n} = \left(\mu_{ij}\right)$, then Step 5 of the game-theory model of ranking IPs under study by their implementation preference level is solution of classical AG, i.e. game set by a completely known matrix. However, if DM has evaluated the precise true values not of all elements of payoff matrix $\mu = \mu_{k\times n} = \left(\mu_{ij}\right)$, then Step 5 of the game-theory model is solution of neoclassical AG, i.e. game set by a partially known matrix. The easiest solution method of neoclassical AG is to transform it into a classical AG.

CONCLUSION

Currently, it is hardly possible to make a sound investment decision without taking into consideration the risk component.

When making an investment decision, one should focus on step-by-step evaluation in order to significantly reduce all kinds of costs related to the pre-investment phase of the project life cycle and to speed up the process of efficient project implementation.

The research paper proposes an IP efficiency evaluation scheme, which includes three levels of evaluation: **1.** IP preliminary estimate; **2.** IP deterministic evaluation (a more accurate evaluation of IP without taking into account risk exposure factor); **3.** Final decision making (selection of a project for implementation, taking into consideration risk exposure factor as well as IP impact on corporate image and strategic development).

Modern science offers no common opinion concerning the best method of risk assessment in investment decision making. In our opinion, the choice of this or that method is subject to a practical situation.

Investment decision making under the conditions of uncertainty, conflict and economic risk is possible on the basis of combined use of statistical and antagonistic games. To find the values of implementation preference levels of the projects under study, it is reasonable to use the model of ranking IPs under study by their implementation preference level based on combined application of antagonistic game theory and fuzzy mathematics.

The game-theory model of ranking IPs under study by their implementation preference level has a number of advantages (for example, the possibility of combining individual analysis for each individually taken project with portfolio approach allowing for comparative analysis of all projects), and a number of disadvantages (for instance, excessive caution during evaluation of project preference level). It is reasonable to apply this model when DM considers that s/he has no right to risk, for example, in a crisis or pre-crisis environment.

If DM has succeeded in defining the precise true values of all elements of payoff matrix, then the game-theory model of ranking IPs under study by their implementation preference level is based on solution of classical AG, i.e. game set by a completely known matrix. However, if DM has defined the precise true values not of all elements of payoff matrix, then the game-theory model is based on solution of neoclassical AG, i.e. game set by a partially known matrix. The easiest solution method of neoclassical AG is to transform it into a classical AG.

Application of the proposed economic and mathematical models in investment decision making allows us to select the best IPs for implementation in terms of optimization of both their efficiency and implementation preference level.

The authors see further investigation in this field in design of methods and models of risk management in investment decision making in the real sector of economy.

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Сигал А. В. О некоторых аспектах учета рисковой составляющей при оценке эффективности инвестиционных проектов / А. В. Сигал, М. А. Бакуменко // Ученые записки Таврического национального университета имени В. И. Вернадского Серия: «Экономика и управление». – 2014. – Т. 27 (66). № 1. - С. 155-165.
В статье предложена схема принятия инвестиционного решения на предприятии, которая предусматривает поэтапную оценку эффективности инвестиционных проектов (в том числе поэтапный учет рисковой составляющей), а также учитывает влияние проекта на имидж и стратегическое развитие предприятия. Проведен краткий анализ наиболее распространенных методов учета риска при оценке эффективности инвестиционных проектов. В статье предложена модель упорядочивания (ранжирования) рассматриваемых инвестиционных проектов по уровню предпочтительности их реализации. Для оценки значений уровней предпочтительности используется сценарный подход и решение соответствующей антагонистической игры, которая моделирует ситуацию принятия инвестиционных решений в условиях неопределенности, конфликтности и порожденного ими экономического риска.
Ключевые слова: инвестиционный проект, оценка эффективности, риск, уровень предпочтительности реализации, сценарный подход, антагонистическая игра, неопределенность, конфликтность.

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