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PROACTIVE MONITORING SYSTEM FOR INVESTMENT PROJECTS: MATHEMATICAL SUPPORT

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Abstract: Investment projects evaluation is considered in the article. Authors offer using developed mathematical apparatus integrated into a proactive monitoring system for the benefit of investment projects assessment. Proactive monitoring systems have a great capacity for improving decision making on entering investment projects, which can be widely used by commercial companies, state bodies, banks, etc. Using mathematical based evaluation systems will help ranking investment projects to select the best and most promising among the available. Based on the study, the author sees it best to apply mathematical models and concentrate on conceptual investment projects for reducing monitoring and evaluation costs, as well as initial development costs. Optimal ways to form expert groups for investment project proactive monitoring is offered in conclusion.

Keywords: proactive monitoring; investment projects; expert groups; hierarchy analysis method; the consequences of the investment project; evaluation criteria.

I. INTRODUCTION

A favorable condition for the development of companies, regions and the economy as a whole is the implementation of investment projects. Top managers of large companies at the present stage have a large number of options for investment projects. But since the investment resources of both private firms and government agencies are limited, in order to get the maximum return on capital investment, the question of choosing a project to invest or delay investment and wait for the right moment has to be approached in more detail.

Currently, methods and models for evaluating the effectiveness of investment projects in the context of complete information are well developed and systematized. However, in reality, almost all investment projects are carried out in conditions of uncertainty, which arises due to the incompleteness and inaccuracy of information about the implementation of the project. In practice, researchers most often encounter cases of probabilistic (when the uncertain parameter of the project is a random variable) and interval (when the uncertain parameter of the project can take values over a certain interval, but the probability distribution is unknown) of uncertainty.

It is essential to determine the optimal time to start investing in conditions of uncertainty, which at the present stage is not sufficiently developed.

The development of the mathematical apparatus for the proactive monitoring of investment projects presented in this article should make it possible to significantly reduce the time spent on evaluating and analyzing an investment project, as well as level undesirable consequences of a project in the future. Already in the early stages, a proactive approach will make it possible to abandon inefficient investment projects, identify vulnerable parties and offer recommendations for their adjustments.

II. LITERATURE REVIEW

Traditionally, to assess the effectiveness of investment projects in the face of uncertainty, a method is used to estimate the expected effect of a project, taking into account the quantitative characteristics of uncertainty. This method allows you to calculate the generalized indicator of project efficiency directly - the expected integral effect, based on which you can directly make decisions about participation or non-participation in the project and compare different projects with each other [1,2]. There are economic and mathematical methods of calculating the expected integral effect of the project, which are based on the fundamental axioms regarding the rational behaviour of the investor for various types of uncertainty, however, the use of these techniques in some cases can lead to incorrect results [1,3,4,5].

One of the significant drawbacks of using these methods in the early stages of investment analysis is that they do not allow for managerial flexibility in analysing the effectiveness of an investment project.

It should be noted that the allocation of resources is the main driving force through which a business strategy for ensuring business continuity can be implemented. If a firm begins to engage in a specific organizational or other investment project, it must regularly and systematically direct and control it at all stages of implementation. A proactive approach during monitoring performs an essential role for the quality analysis of both existing and future projects ensuring the economic security of the business.

Proactive control in the works [4,6] is aimed at preventing deviations and failures. To this end, the components of the external and internal environment of the organization are monitored, deviations in ongoing processes are identified, possible negative consequences are modelled, and necessary adjustments are made to prevent undesirable consequences.

III. METHODOLOGY

The system of proactive monitoring of an investment project proposed in this article is an investment decision support system that has the ability to adapt to future developments related to investment projects by taking into account all the most significant consequences of its implementation (completeness of the consequences system) [7].

For a preliminary analysis of alternative conceptual projects available to the company, a project analyst is appointed who performs preliminary examination and excludes obviously unacceptable project ideas from further consideration based on the criteria established in advance. A conceptual project may be rejected for a number of reasons: insufficient demand for the project's products or the lack of its real advantages over similar types of products; excessively high cost (in terms of not only economic, but also social or, for example, environmental parameters of the project); the lack of necessary guarantees from the project's customer (or government); excessive risk; high cost of raw materials.

The process of preparing and organizing expertise within the framework of proactive monitoring of conceptual investment projects involves solving a number of problems, some of which are determined by the specifics of the project. These problems can be of varying degrees of complexity, and time and considerable resources may be spent on their solution, which in the future, with a competent study of the project, will pay for itself many times over. However, there are problems that have a classic, principled and general character for all examinations: first, the formation of expert groups; secondly, the development of procedures for the collection of expert information; thirdly, the analysis, evaluation and interpretation of the obtained expert data in the framework of proactive monitoring.

Experts are able to formulate a decent response to political, economic, social and other challenges, because, as participants in the process, they have a premonition to take exact preventive measures and are ready to consciously use the resources at their disposal [8,9].

Judgments about future events — in this case, future cash flows of investment projects — made as absolute values are almost always unreliable. At the same time, in the theory of investments there is an invisible image of an economically expedient decision-maker who is able to accurately predict future events and make accurate estimates of the cash flows of investment projects [10].

With the help of cash flow, you can build a model of a conceptual investment project. This model allows you to take into account all the consequences of the implementation of investment projects. The investment project can be formalized in the form of a vector formed by the multi-temporal consequences of the project. These consequences can be benefits, costs, opportunities and risks.

Investment projects can be designated by letters IP1, IP2, IP3, etc. Consider a discrete model of an investment project. Let be some sequence of moments of time, such that $t1 < t2 < ... < tn$. Suppose that the consequences of an investment project IP1 are opportunities, then this project can be represented as a vector, the coordinates of which are some result of the project: as an increase in the scope of the project if it is successful; project sales if it fails; development of related activities, using the experience gained on the first project, etc., obtained at time tj. That is, it is assumed that the elements of the vector IP1 correspond uniquely to the elements of the sequence {t}. Consider two independent projects IP1 and IP2, that is, those where the implementation of one of them does not affect the costs and results of the other. Let these projects be represented as vectors IP1 = (x1, ..., xn) and IP2 = (y1, ..., yn). If both projects are implemented jointly, the consequences at step j on the first project will be xj, on the second - yj. The system of proactive monitoring of investment projects as a criterion when choosing the most effective project portfolio uses the integral effect E (IPn). In this case, the integral effect E (IPn) becomes a function of the effects obtained at each step: E (IPn) = E (x1, ..., xn) Obviously, the project IPn is effective if E (IPn)> 0, and ineffective, if E (IPn) <0. Of several alternative projects, the one that has the most effective consequences of implementation is most effective. Therefore, instead of evaluating the project's effectiveness, one can limit oneself to applying expert knowledge of taking into account the totality of the consequences of a project.

Therefore, in order to increase the efficiency of investment decisions, such a toolkit, which would allow to work with judgments made by experts in the form of relative assessments [11], could greatly contribute.
Hierarchy analysis method (HAM), which is based on a rigorous mathematical eigenvector method for processing inverse-symmetric matrices (matrices with power calibration) [6, 9].
When we deal with a lot of conceptual alternative investment, their detailing is very time consuming. The work on the study of conceptual investment projects should be entrusted to a group of experts, which should include experts in a specific field of investment.

Of course, one of the most important characteristics of a second-hand investment project is the risks of its implementation. It may happen that at the pre-investment stage, prognostic information will be obtained about excessively large risks; In this case, it is necessary to develop recommendations on adjusting the investment project itself, postponing its development and implementation for a certain period. This will undoubtedly contribute to the rational and optimal use of resources [11]. Thus, it becomes possible:
- adjustment of objectives (target functions) of the investment project;
- possible correction of the investment project itself;
- adjustment of infrastructure at different levels according to the targets of investment projects and innovation policy.

IV. RESULTS AND DISCUSSION

The system of proactive monitoring of an investment project provides for the need to evaluate the effectiveness of an investment project with different depth of study at various stages of its development and implementation. But the very concept of "depth of study" remains uncertain.

It is assumed that each conceptual investment project can be adequately described by the list of consequences.

IP=({B, C, O, R}^{1},….., {….}^{1}), where

B-benefits;
C-costs;
O-opportunities;
R-risks.

Thus, under the evaluation of the effectiveness of investment projects at the t-th step of the calculation period in the framework of the proactive monitoring system, we will understand this assessment, which takes into account the full set of consequences that occurs at this step:
- cash inflows minus current expenses, or cash inflows (cashinflows) (“benefit” criterion);
- investment costs or cash outlays (“cost” criterion);
- management capabilities (criterion of "opportunities");
- cash flow risk (“risk” criterion).

Let’s introduce the notation for the relevant functions of the investment project evaluation:
φtB(ip)— evaluation function from the standpoint of the “benefits at the t-th step of the calculation period”;
φtC(ip)— evaluation function from the standpoint of the criterion "costs at the t-th step of the billing period",
φtO(ip)— evaluation function from the standpoint of the “possibility at the t-th step of the billing period” criterion,
φtR(ip)— evaluation function from the standpoint of the “risks at the t-th step of the billing period” criterion.

By aggregating these functions, we obtain the evaluation function (φt) of the investment project with respect to the criterion “value of the investment project at the step of the calculation period”, which we formally define as follows:

φt: IP→Vt,

where IP is the set of investment projects (IP ={ipi, i=1,m}),

Vt is a set of numbers enclosed in the interval from 0 to 1, reflecting the “value” (evaluation) of the investment project at the t-th step of the calculation period.
In the present study, we use the multiplicative form of the aggregation operation, which in our notation is:

$$\varphi_t\,(ip) = \frac{\left(\begin{matrix} B \\ \varphi_{\mathrm{t}} \end{matrix}\right)^{wB} \left(\begin{matrix} O \\ \varphi_{\mathrm{t}} \end{matrix}\right)^{wO}}{\left(\begin{matrix} C \\ \varphi_{\mathrm{t}} \end{matrix}\right)^{wC} \left(\begin{matrix} R \\ \varphi_{\mathrm{t}} \end{matrix}\right)^{wR}},$$

where wB is ″ weight ″, priority of the “benefit” criterion,
wO is ″ Weight ″, priority of the “opportunity” criterion,
wC is ″ weight ″, priority of the “cost” criterion,
wR is ″ weight ″, the priority of the criterion "risks".

Graphically, the function “value of the investment project at the t stage of the calculation period” has the following hierarchical structure (Figure 1).

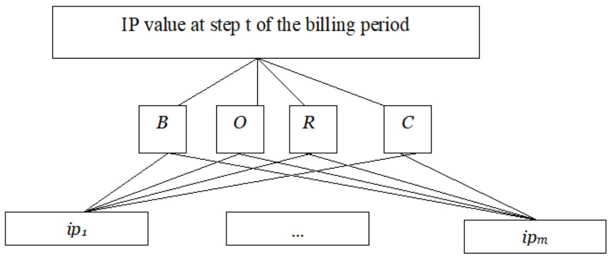

Fig. 1 The hierarchy of the value of the investment project (IP) at step t of the billing period

It should be noted that each of these criteria can be refined by subcriteria.
For example, for the "opportunity" criterion, the following refined hierarchy of Figure 2 may occur.

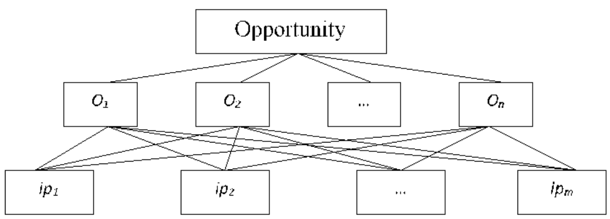

Fig. 2 Hierarchical evaluation model from the standpoint of the "Benefits" criterion.

Experts from the formed expert group, evaluate the projects according to the following set of criteria "Opportunities": 1. The development of related activities; 2. Increasing the scope of the project; 3. Sale of the project.
We construct matrices of pairwise comparisons with respect to the goal of "Possibility," each criterion (table 1).

Table 1: Matrix of paired comparisons.

Opportunities	**Development of related activities**	**Scaling up project**	**Sale of project**
Development of related activities	1	4	4
Scaling up project	1/4	1	2
Sale of project	1/4	1/2	1

The results of the calculations we present in table.2

Table 2: Priority of criteria and restrictions regarding the leading goal (compiled by the author).

Criterion	**Eigenvector (Wk)**	**MAX eigenvalue**
Development of related activities	0,661	3,054
Scaling up the project	0,208	
Project sale	0,131	

Next, experts evaluate alternatives to solving the problem according to the criteria (table 3).

Table 3: Matrix of paired comparisons of the expert 1 by criterion "Development of related activities".

Development of related activities	**Project No. 1**	**Project No. 2**	**Project No. 3**
Project No. 1	1	2	7
Project No. 2	1/2	1	4
Project No. 3	1/7	1	1

The results of the calculations we present in table 4.

Table 4: Priority of investment projects in relation to the criterion "Development of related activities" expert No. 1.

Criterion	**Eigenvector (Wk)**	**MAX eigenvalue**
Project No. 1	0,603	3,002
Project No. 2	0,315	
Project No. 3	0,082	

Similarly, matrices of pairwise comparisons are constructed relative to other criteria "Scale up of the project", "Project sale"

V. Conclusion

In order to increase the efficiency of an investment project a proactive monitoring system introduction is advised. Such a system is based on data and key parameters consideration and detecting project development patternes based on the information obtained. Closely calculated development tendencies will help avoid risks and undesirable patterns in the future investment projects.
Developed mathematical system of proactive monitoring will provide an opportunity to analyse the investment project as it goes, in order to make timely adjustments, introduce improvements, prevent money loss or halt the project if necessary. Bringing a complete description of the consequences of a conceptual investment project implementation allows to choose the most promising and profitable projects, which fully correspond to the current economic situation and market trends.
Evaluating the project implementation adequately implies calculating costs, benefits, opportunities and risks. These are the 4 cornerstone criteria for project assessment.
Evaluating these key data based on the time-framework scale will give proactive monitoring system the best chance to illustrate full consequences of implementing every step of the project.
This includes cash flow simulation on every step of the project, which will help assess the risks and the benefits of the project on offer. Introducing expert assessment in

addition to proactive monitoring mathematical system will give the best picture of the future project development.

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