An Optimization Multicriteria Model of Managerial Decision Making About the Efficiency of Choice of the Enterprises' Strategic Assets

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Abstract — **Management activities are closely linked to the development and adoption of effective decisions about various managerial situations and are an important foundation for the successful operation of domestic enterprises. At the same time, the most difficult decisions are taken in conditions of uncertainty and risk when it is not possible to estimate the probability of potential results. Therefore, the purpose of the article is to optimize the multicriteria model of management decision making under the conditions of uncertainty and risk.**

As a result of the research, the multicriteria model of making managerial decisions about the effectiveness of the choice of strategic assets for the machine-building enterprises under the conditions of uncertainty and risk is optimized; the stages of development and selection of managerial decisions. In order to manage the investment activity of the enterprise and ensure the implementation of all measures of investment policy, the criteria for the effectiveness of the investment policy of the enterprise are presented.

Keywords — multicriteria model, management decision making, investment activity, uncertainty, risk, investment policy

I. INTRODUCTION

Market relations in the domestic economy continue to be complicated, Ukrainian enterprises are forced to function in conditions of intensifying competition, increasing the impact of crisis phenomena, rapid changes, lack of clear development benchmarks, unpredictability, uncertainty and diverse risks.

In the modern volatile environment the management team of enterprises has to make decisions that should ensure the effective operation of the enterprise, allow it to occupy its niche in the market, to introduce innovations, to produce competitive products.

The domestic investment sphere, on the one hand, acquires important socioeconomic significance for the development of the country, but, on the other hand, the lack of a conception of structural adjustment of the economic system creates negative conditions for the integrity of the investment complex, the interaction and integration processes of its components.

The reduction of investment attractiveness of enterprises, deterioration of the quality of products of domestic producers proves the inability of management to take effective management decisions in the conditions of uncertainty and risk. Managers are not always able to analyze the situation correctly, see the prospects and, according to it, to take decisions that strategically important for enterprise development, especially in a changing environment. Therefore, an increasingly important issue becomes the adoption of effective managerial decisions that would be based on an analysis of external and internal factors that effect on the activities of enterprises. In this regard, the role of theoretical research and practical developments in strategic decision making, considering risk factors and uncertainty, is substantially increasing.

II. LITERATURE REVIEW

Starting from the end of the XIX century and to this day, the problems of developing, adopting, implementing, assessing the effectiveness of managerial decisions are given more attention. This is evidenced by the numerous fundamental publications of foreign and domestic scientists [1],[2],[3],[4], [5], [6], [7].

Such foreign scientists as O. Negulescu and E.Doval [1], A. Orlov [2], P.Terelyansky [3] and others are made a significant contribution to the research of the problem of making managerial decisions under conditions of uncertainty.

O. Negulescu and E. Doval in their article [1] to investigate the managers and employees' opinions about the quality the decisions are making in different domains in correlation with the organizations' objectives and to draft a conceptual model, selecting the main drivers that contribute to the approach of the managers to focus their decisions towards the organizations' effectiveness.

The methods of developing management decisions are presented in research [2]. The basics of decision theory, technology and development and adoption procedures are considered.

The basic concepts and paradigms of decision theory are presented in the book [3]. The description of the most used mathematical ranking methods is given, general information on comparative scales, measurement theory.

The questions of managerial decisions in conditions of uncertainty were also investigated by domestic scientists such as V.D. Bakumenko [4], O.H. Makarchuk [5], T.S. Obydenova [6], Yu.E. Petrunya [7] and others.

The authors consider the essence of the management decision and its place in the management system, the classification, requirements for management decisions, information and analytical support of the process of making informed managerial decisions, stages and methods of development and adoption of managerial decisions, some methods for assessments of their efficiency, effectiveness and quality are presented.

In particular, V.D. Bakumenko in the educational manual "Government-management solutions" [4] comprehensively and systematically examines the theory, scientific and practical methodology for developing, adopting and implementing managerial decisions.

The reseach of O.H. Makarchuk [5] deals with the peculiarities of the application of methods of strategic management decisions in the conditions of uncertainty: that helps to ensure the development of the enterprise and its survival in a competitive environment.

The development of an algorithm for forming a managerial decision on the need for structural transformations of industrial enterprises are considered in the article [6]. At each of the stages of the algorithm of formation of decision-making on the need for structural transformations of industrial enterprises, a comprehensive assessment of the components of complex diagnostics of financial and economic activity is carried out.

The scientific work "Adoption of managerial decisions" [7] contains a comprehensive statement of the basics of the theory and practice of making managerial decisions expressed in the organizational, economic, mathematical, psychological and heuristic aspects of this process. Particular attention is paid to the target orientation of managerial decisions, the directions of reducing uncertainty and risk, the use of scientific methods of development and the adoption of managerial decisions in accordance with specific conditions.

III. PROBLEM DESCRIPTION AND METHODOLOGY

The purpose of the article is to identify ways to optimize the process of making managerial decisions in conditions of uncertainty and risk. On the basis of the conducted research, it is necessary to form the stages of development and selection of managerial decision about the effectiveness of the choice of strategic assets for the machine-building enterprises, which is considered as a set of controlled and uncontrolled variables, criteria for assessing alternative options for possible decisions, decisive rules and alternatives for selecting and justifying an optimal management solution.

Methodology. In the process of research, methods of analysis and synthesis, techniques of inductive and deductive analysis are used. Empirical methods in the analysis of statistical information are used. Methods of paired comparisons, rankings, ball scores, direct numerical estimation are used to determine the coefficients of the relative importance of the criteria for selecting strategic assets of enterprises. Linear interpolation procedure is used to construct a coherent scale for a separate criterion and utility function. The method of hierarchy analysis is used to provide a multicriteria characteristic of the problem of making managerial decisions about the effectiveness of the choice of strategic assets of machine-building enterprises and determining the efficiency of the investment policy of the enterprise

IV. RESULTS AND DISCUSSIONS

The formation of strategic assets of machine-building enterprises involves the consideration of a significant number of factors that need to be taken into account in the process of making a managerial decision to choose the optimal option from many possible ones. In such circumstances, the adoption of an effective solution requires the definition of a clear goal, accurate data on the conditions for making a decision, reasonable information about all possible alternatives and a rational system for organizing the benefits of their degree of importance. The process of making a management decision involves the presence of such components as managed variables - a set of factors and conditions that cause the emergence of a particular problem that may change as a result of the managerial decision by the entity; unmanaged variables - situations on that can't be influenced the subject of a management decision, but which may change under the influence of other conditions; restrictions on the value of managed and unmanaged variables that collectively determine the permissible values of possible solutions; criterion (or criteria) for the evaluation of alternative options for possible solutions, the criterion may be given by a quantitative model or qualitatively (in terms of individual preferences or in terms of fuzzy logic); decisive rule (or system of decisive rules) - principles and methods of choosing a solution that results in the application of which receives recommendations or a substantiated decision; alternatives (possible outcomes), depending on both the values of qualitative or quantitative managed and unmanaged variables, and on the choice [8]. So, taking into account many factors and components in the process of making managerial decisions is ensured by the application of scientific methodological approaches and mathematical tools for making managerial decisions. For this purpose, we consider the possibility of applying a multicriteria model for making managerial decisions proposed and adapted by scientists to make decisions of this type [8].

Making a decision about the effectiveness of strategic assets choosing for machine-building enterprises is a relatively new task, which has no previous (actual) data that reflects certain traditional aspects or experience of forming strategic assets of the enterprise, as well as unknown further effects on the magnitude of their formation and features of further use [9],[10],[11].

The main purpose of developing a multicriteria model for solving the production situation is to develop a target criterion (rule) <C> of making a decision that allows to install a reasonable compromise between the values of all model's components for the collective making managerial decisions, as confirmation of the decision making about formation of strategic assets of the enterprise, its choice will be based on the collegial work of the whole team, its structural divisions, on the knowledge and experience of practical activities of specialists. Such rule is the ensuring of the effectiveness of activities as a result of formation of strategic assets of machine-building enterprises.

The criterion model (*CM*) of decision-making can be represented as a function:

$$CM=<T, S, K, X, F, C>, \qquad (1)$$

where *T* - task of decision-making; *S* - the set of admissible decision options; *K* - the set decision evaluation criteria; *X* - set of scales; *F* - display of the set of admissible solutions in the set of vector estimates; *C* - target criterion (rule) of decision making.

The task of decision-making (*T*) corresponds to the target criterion of making a decision on the formation of strategic assets by machine-building enterprises. The purposeful statement of the problem requires finding the most attractive solution for each machine-building enterprise, taking into account the peculiarities of its functioning. The set *S* is a set of many solutions, taking into account certain constraints that are considered as possible ways of achieving the goal of forming a certain type of strategic assets of an enterprise for a clearly defined amount. The elements of the *S* set at the decision of production situation are also called admissible solutions, strategies or alternatives. Each solution acquires its definite value (result), which is evaluated according to predetermined criteria K_1, K_2, ..., K_m.

During the formation of strategic assets for machine-building enterprises, the term criteria should be understood as indexes that are recognized by management as an important part of the assessment of the entire process of formation of strategic assets, is common to all permissible decisions, for each machine-building enterprise and characterize the overall value of the solution in such a way that managers try receive the most reliable estimates for the type of strategic assets, costs for their formation and total cost. For each criterion a scale is constructed, which is an ordered set of estimates.

The models of multicriteria tasks of making management decisions and their implementation provide for the implementation of complex procedures, which include formalized and non-formalized stages. To solve the problem of choosing strategic assets of machine-building enterprises, we will propose a sequence of stages for selecting the best options (Fig. 1).

As a method of determination the coefficients of the relative importance of the criteria for choosing strategic assets of machine-building enterprises, can be used such economic and mathematical methods as the method of pair comparisons, ranking, ball assessments, direct numerical evaluation. The traditional element of such a process is the main purpose of constructing the agreed quantitative scales -

bringing the output data to a comparable form and taking into account the features of determining the advantages (target criteria) of the options of choice for each criterion.
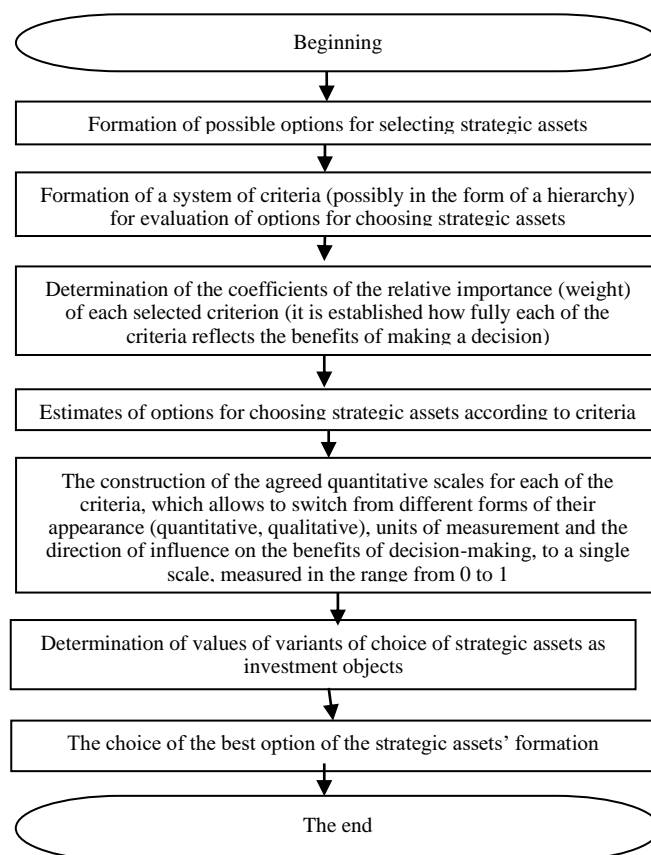

Fig. 1. The choice of the best option for the strategic assets' formation as objects of financing of investment activity (source: built by authors on the basis of [9; 10; 11])

The most commonly used method for constructing an agreed scale for a particular criterion or utility function is the linear interpolation procedure, the essence of which is that the variant with the criterion value that is least acceptable (X_0) is assigned 0: $Y_0 (X_0) = 0$, respectively the option with the most acceptable (X_1) is assigned 1: $Y_1 (X_1) = 1$. The utility function is defined as a system of equations:

$$\begin{cases} Y_0 = a_0 + a_1 \cdot X_0 \\ Y_1 = a_0 + a_1 \cdot X_1 \end{cases} \qquad (2)$$

Then, from the system of equations (2), the coefficients a_0 and a_1 can be defined as:

$$a_0 = \left(X_0 \times Y_1 - X_1 \times Y_0 \right) / \left(X_0 - X_1 \right) \qquad (3)$$

$$a_1 = \left(Y_0 - Y_1 \right) / \left(X_0 - X_1 \right) \qquad (4)$$

Substituting the values of *X* into the equation $Y = a_0 + a_1 \times X$ makes it possible to determine the agreed quantitative utility values for other criteria values. We will use the proposed approach to determine the option of

selecting strategic assets as investment objects of investment activity of machine-building enterprises: strategic assets for the production of new types of products (B_1), strategic assets for investment projects for the production of new types of products and technological developments (B_2), strategic assets for the introduction of the latest production and management technologies (B_3). The main benchmark for choosing a strategic asset option for each machine-building enterprise will be the recommended cost and direction of their use in order to ensure the development of the company in the face of crisis phenomena and prevent their further lagging behind the accelerated pace of technological processes in the field of mechanical engineering as well as in other sectors of the national economy.

The task definition and the choice of the best variant of strategic assets for each machine-building enterprise require the definition of the main criteria for making investment decisions: the costs associated with the formation of strategic assets of the enterprise (K_1); the size of the source of funding for the acquisition of strategic assets remaining at the disposal of the enterprise to further finance the investment process after deducting the initial cost of acquiring strategic assets (K_2); the level of risk of investment activity of machine-building enterprises (K_3); the level of development of active markets, where is possible the acquisition of strategic assets of the enterprise (K_4); the degree of influence of regulatory restrictions on the choice of the type of strategic assets of the enterprise as an investment object (K_5).

The risk of investment activity of machine-building enterprises is connected with the uncertainty of the prospects of the country's economy, financial instability (the risk of financial losses in the process of strategic assets' acquiring, attracting sources of financing), increased interest on loans, increased production costs, increased environmental standards, changes in demand for products, changes in the quality of products, the emergence of competing products, the lack of labor resources, etc. In order to determine the coefficients of relative importance (weight) it is expedient to apply a method of direct expert evaluation using a ball scale from 1 to 10, where 10 corresponds to the highest importance of the criterion, and 1 - the smallest. The method of determining the degree of risk by expert assessments has subjective character. This subjectivity is the result of the fact that a group of experts, which deals with risk analysis, expresses its own subjective judgments about both the past situation and the prospects for its development. The optimal variant of the choice of strategic assets for a machine-building enterprise is formed on the basis of the relative importance factor (weight) of the criteria for selecting strategic asset options of the company "A".

TABLE I.   WEIGHT OF THE CRITERIA FOR CHOOSING OPTIONS OF STRATEGIC ASSETS OF THE COMPANY "A"

Criteria	Evaluate the benefits of the criteria, score	Relative importance of the criteria (weight)
K_1	6	0,15
K_2	3	0,11
K_3	9	0,30
K_4	8	0,27
K_5	5	0,17

(source: built by the authors)

The estimation of options for choosing strategic assets as objects of investment activity according to the criteria of advantage is given in Table 2.

TABLE II.   ESTIMATION OF OPTIONS FOR CHOOSING STRATEGIC ASSETS AS OBJECTS OF INVESTMENT ACTIVITY ACCORDING TO THE CRITERIA OF SELECTING COMPANY "A"

Criteria	Strategic assets		
	B_1	B_2	B_3
The expenses related to the formation of strategic assets of the enterprise (K_1), conventional units	200158	240189	260250
The size of the funding source for the acquisition of strategic assets that remaining at the disposal of the enterprise for further finance of investment process after deducting the initial costs for the acquisition of strategic assets (K_2), the conventional units	800632	760600	740584
The risk level of investment activity of machine-building enterprises (K_3)	6	8	3
The level of development of active markets, where the acquisition of strategic assets of the enterprise are possible (K_4)	4	5	8
The degree of influence of regulatory restrictions on the choice of the type of strategic assets of the enterprise as an investment object (K_5)	7	4	1

According to the presented values, the costs associated with the formation of strategic assets of the enterprise (K_1), the linear interpolation procedure for company "A" is calculated as follows: the variant with the value of the criterion K_1, which has the smallest advantage ($X_0 = 260250$) conditional units is assigned 0: $Y_0 (X_0 = 260250) = 0$, respectively, the biggest advantageous option ($X_1 = 200158$ conditional units) is assigned 1: $Y_1 (X_1 = 200158) = 1$. The coefficients a_0 and a_1 are:

$$\alpha_0 = (0*200158 - 1*260250) / (0-1) = 260250$$

$$\alpha_1 = (260250 - 200158) / (0-1) = -60092.$$

Substitution of value X_2 - 240189 conditional units into the equation $X = a_0 + a_1 Y$ or $Y = (X-a_0) / a_1$ makes it possible to determine the agreed quantitative value $Y (X_2) = (240189-260250) / (-60092) = 0.334$.

The results of the conversion from the absolute values of parameters in the relative (comparative quantitative) values of company "A" based on the procedure of linear interpolation is shown in Table. 3

TABLE III.   CONVERSION THE ABSOLUTE VALUES OF CRITERIA OF VARIANTS' ESTIMATIONS INTO COMPARATIVE VALUES OF COMPANY "A"

Criteria	Strategic assets		
	B_1	B_2	B_3
K_1	1	0,334	0
K_2	1	0,334	0
K_3	0,47	0	1
K_4	0	0,38	1
K_5	0	0,334	1

(source: built by the authors)

Then the aggregation (collapse) of the obtained comparative assessments of the advantages of the criteria

and ratios of the relative importance (weight) of the criteria for each of the variants of financing sources of investment activity is made (Table 4).

TABLE IV.   CALCULATION OF THE RESULTS OF AGGREGATED VALUES OF THE ADVANTAGES OF THE INVESTMENT FINANCING SOURCES OF THE COMPANY "*A*"

Criteria	Weight criterion	Strategic assets		
		B_1	B_2	B_3
K_1	0,15	1×0,15=0,15	0,334×0,15= =0,05	0×0,15=0
K_2	0,11	1×0,11=0,11	0,334×0,11= =0,038	0×0,11=0
K_3	0,30	0,47×0,30==0, 14	0×0,30=0	1×0,30=0,30
K_4	0,27	0×0,27=0	0,38×0,27= =0,103	1×0,27=0,27
K_5	0,17	0×0,17=0	0,334×0,17= =0,056	1×0,17=0,17

(source: built by authors)

The aggregate value of decision-making advantages obtained on the basis of this ratio allows sorting order options for choosing strategic assets as objects of investment activity and making the most appropriate choice of variant. Herewith there is an intensification of the investment activity of the enterprise.

Managing the investment activity of the enterprise and ensuring the implementation of all measures of investment policy requires an assessment of its effectiveness according to these criteria (Fig. 2).

Fig. 2.   Criteria for the effectiveness of the investment policy of the enterprise (source: developed by authors for [12] and supplemented)

The conformity of the investment policy with the selected criteria will ensure its effectiveness and the ability to obtain the expected economic effects from the implementation of investment processes.

On the basis of investment policy, the management of the An assessment of the effectiveness of the investment policy of machine-building enterprises can be made on the basis of evaluation of the results of their activities and investment activity (profitability), as well as on the basis of the received social or environmental effects.

V.   CONCLUSIONS

In difficult economic conditions the investment policy is formed at the at the machine-building enterprises, which allows focusing on the effective use of material resources through the production of innovative or traditional products. Adoption of managerial decisions at a machine-building enterprise, which functions under conditions of uncertainty and risk, involves the identification of optimal solutions, using a multicriterion model, which ensure the effective activity of the enterprise and promote its innovative development. Herewith as an optimal solution of the multicriterion model, an alternative is chosen, which is characterized by the highest value of the criterion of total efficiency.

The research results can be used by enterprises to develop and construct models for optimizing management decisions. In modern conditions of the development of innovative technologies, there is a need to adopt an optimal solution for the effectiveness of the choice of strategic assets of enterprises in conditions of the variability of the environment, uncertainty and risk.

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