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THE SYSTEM APPROACH TO MAKING MANAGEMENT DECISIONS UNDER UNCERTAINTY

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Abstract

In the management of the organization, decision-making acts as a binding process for main functions: planning, organizing, motivating and control. Selection and justification of specific decisions is based on the concept and methodology of the theory of managerial decisions under uncertainty. An important feature of the processes of managerial decision-making is the need to consider the impact of uncertain factors and all possible consequences of alternatives presented for choice. The adoption of any decisions under risk and uncertainty is essential for the management of the organization. Management decision cannot be made without a rational approach to the analysis, substantiating its effectiveness. The article proposes the definitions of “management decisions” and “uncertainty”, based on the study of scientific literature. The authors present: stages of the production process and managerial decision-making; main approaches, peculiarities and system of managerial decision making in conditions of uncertainty; algorithm of acceptance of optimum administrative decisions and the “decision matrix” for making managerial decisions in conditions of uncertainty. The authors consider and compare Wald criterion and Hurwitz criterion, used when comparing alternatives in situations of uncertainty.

Keywords: Uncertainty, models, matrix, management decisions, risks

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1. Introduction

An important feature of managerial decision-making processes is the need to take into account the influence of uncertain factors and consider all the possible consequences of the alternatives that are presented for selection, where, in the face of uncertainty, the development of managerial decision-making models is of great practical importance.

2. Problem Statement

The problem of making managerial decisions in the face of uncertainty is relevant and important for consideration, since it is the main tool for managing influence.

Issues of making managerial decisions in the face of uncertainty are reflected in the works: V.A. Durdenko, S.V. Spiridonova, B.G. Litvak, A.I. Orlova, E.Yu. Kuzmina, L.A. Birman, E.I. Brazhko, A.G. Ivasenko, R.A. Fathutdinova, V.N. Kodina, S.V. Lityagina, L.I. Lukicheva, D.N. Egorycheva, A.P. Chernikova, E.E. Dosuzhevoi, E.V. Potapova.

A managerial decision is a choice that a leader makes in the management process and for solving specific organizational problems. A managerial decision aims to ensure progress towards the goals set for the organization. Therefore, the most effective management decision is an implemented choice that will make the greatest contribution to achieve the ultimate goal (Borodin & Borodina, 2015).

Managerial decision-making process is one of the elements of independent management of the organization and it is significant for Russian entrepreneurs.

The process of making management decisions should be an algorithm that is maximally suited to solving problems in managing the organization. The main problem in this process is the need to choose the best solution from the many possible ones or to order options according to their preference. In this case, the result is the receipt of recommendations and forecasts, which are not a direct indication of further actions (Babushkina & Slabinsky, 2015).

According to Samotina and Potapova (2011) uncertainty is “open tasks in which the decision maker does not know the totality of the factors involved and must formulate many hypotheses before evaluating them”. The situation of complete uncertainty is characterized by the fact that the choice of a specific action plan can lead to any outcome from a fixed set of outcomes, but the probability of their implementation is different. Uncertainty can be caused by socio-political, administrative-legislative, production, commercial, financial and other factors, as well as rapidly changing circumstances (Kudryashov & Platonova, 2016). Uncertainty associated with the possibility of adverse situations and consequences during the implementation of the project is characterized by the concept of risk (Sapunova, 2010). In economic activity, there is almost always uncertainty (Yashchenko, 2013).

3. Research Questions

Management decision-making models help to ensure the structuring and processing of information about the problem and, thus, partially make up the incompleteness of the data available to the head (Golovin & Koroleva, 2013). Nevertheless, recommendations for decision making, obtained with

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the help of abstract models, can be considered as a way to solve problems only when the uncertainties and risks in these decisions are predicted and taken under control.

4. Purpose of the Study

The main goals and features of the managerial decision-making process in the face of uncertainty are (Busov, 2013): limited source data; large number of restrictions and assumptions, expressed in an explicit form; the absence and inability to mathematically formalize the objective function; the influence of random risk factors; taking into account all possible consequences of alternative assumptions; the choice of mathematical apparatus and the formation of the necessary model (Macheret & Kudryavtseva, 2016).

The system of managerial decisions in the face of uncertainty is presented in Figure 1.

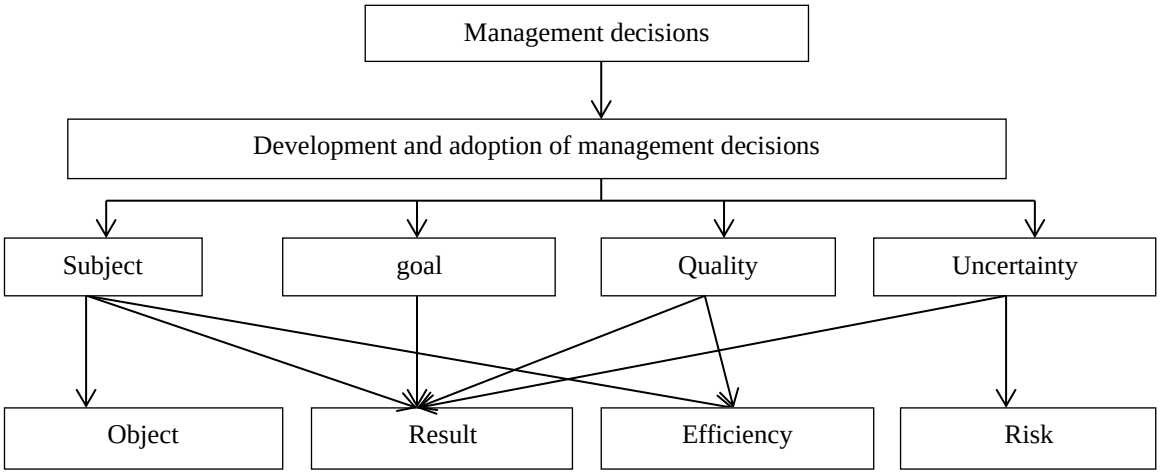

Figure 1. The system of managerial decisions in the face of uncertainty

The management decision-making process goes through the stages presented in Figure 2.

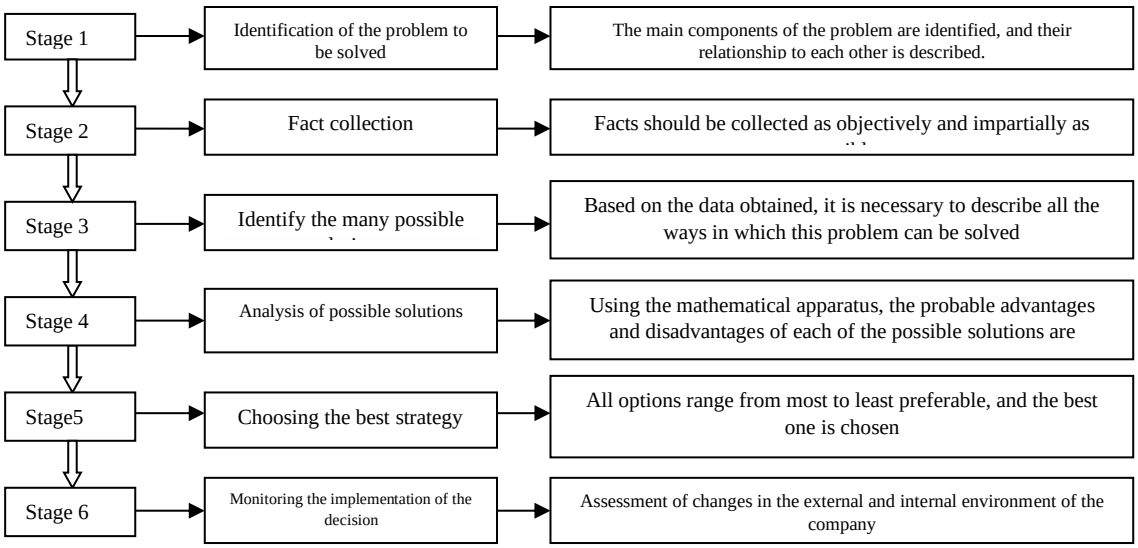

Figure 2. Management decision making process

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The main features of management decisions are presented in Figure 3.

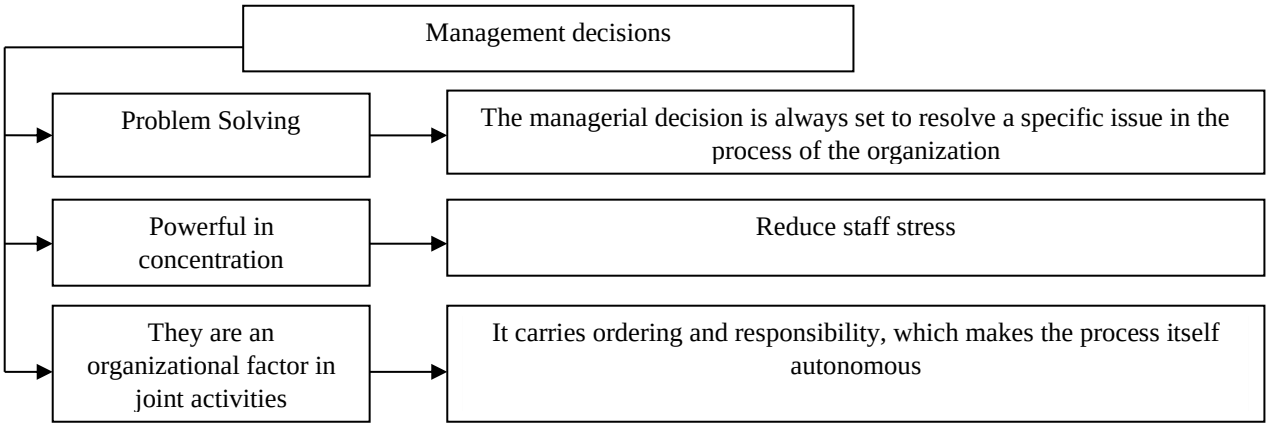

Figure 3. Features of management decisions

The process of production and implementation of management decisions consists of six stages, and is presented in Figure 4.

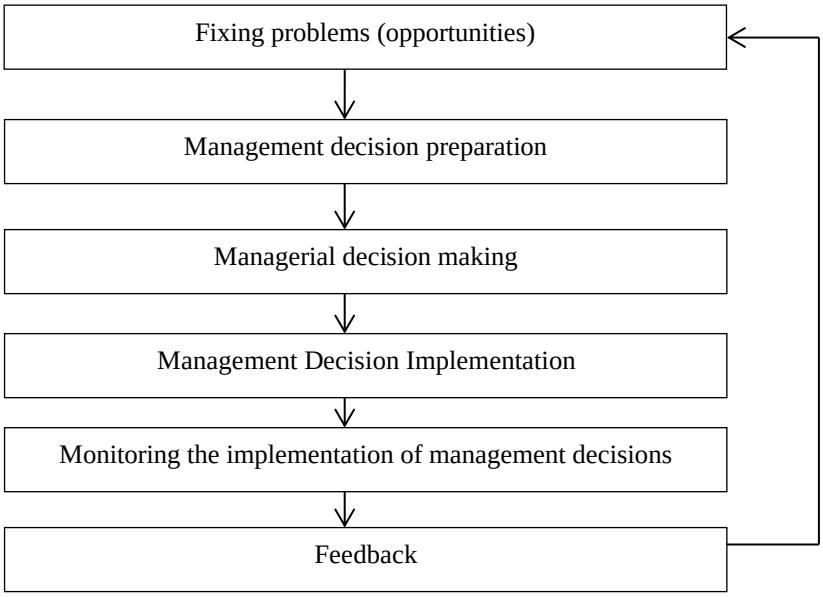

Figure 4. The process of production and implementation of management decisions

To develop an optimal management decision, it is necessary to highlight the patterns of development of the situation, to predict the onset of crises and to form strategic rules in accordance with which decisions are made (Vasilenko et al., 2018).

There are four main approaches to making management decisions in the face of uncertainty: 1) deterministic; 2) probabilistic; 3) fuzzy sets; 4) system (table 1).

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Table 1. The main approaches to making management decisions in the face of uncertainty

Approach	Characteristic
Deterministic	allows the manager to have almost complete and reliable information regarding the problem being solved and to know exactly the results of alternatives
Probabilistic	includes results that are not certain, but the probability of each result is known
Theory of Fuzzy Sets	increases the validity of the management decision-making process, since many of the data obtained by collecting opinions on a particular problem cannot be represented by a single number, but represent some verbal assessments
Systems approach	based on the following basic principles: systematicity, hierarchy, integrality and formalism, and on some combination of fundamental concepts: system, element, subsystem, external environment, factor, value, usefulness, purpose

The algorithm for substantiating optimal management decisions in the face of uncertainty is presented in Figure 5.

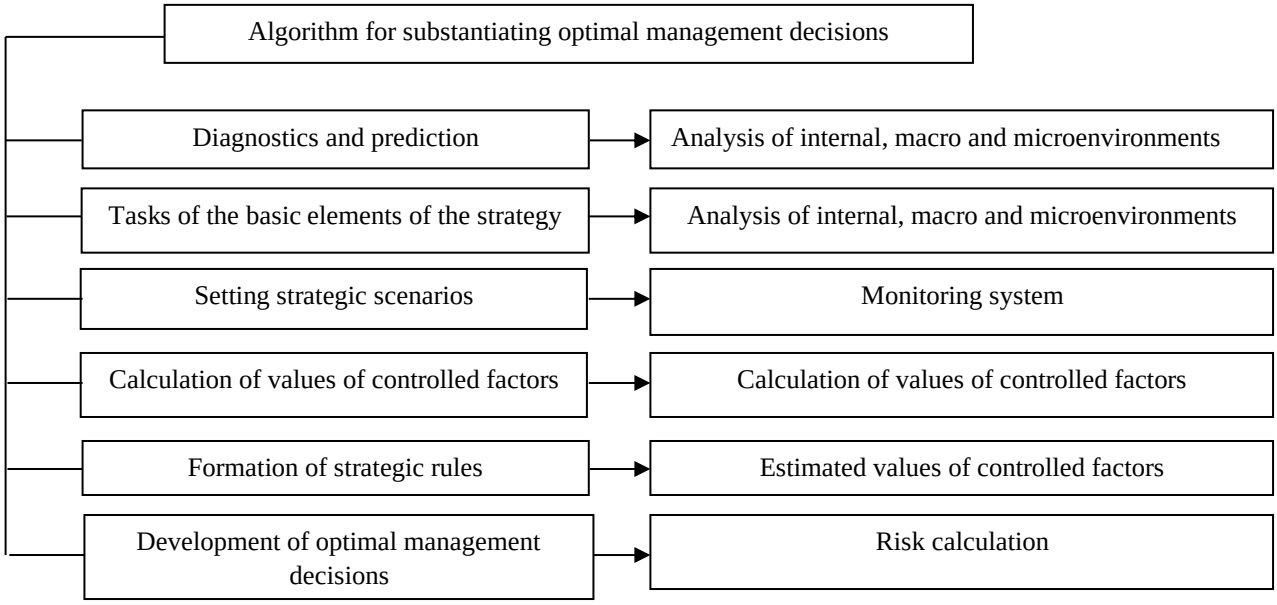

Figure 5. Algorithm for substantiating optimal management decisions in the face of uncertainty

It is worth noting that the uncertainty situation includes several alternative solutions, each of which is a set of outcomes that take into account the corresponding state of the organization's functioning environment (Sokolov, 2015). For a reasonable comparison of the set of values of each alternative and the choice of the most optimal option, it is effective to apply various selection criteria (Tagiltseva et al., 2017).

5. Research Methods

Decision making in the face of risk and uncertainty involves the construction of a "decision matrix" to justify it. The "decision matrix" is presented in table 2 (Shapkin, 2015). In the matrix, the indicated values are A1; A2; ...; An denote options for alternatives to decision making. C1 values; C2; ...; Cn characterize each possible variant of how further events can develop. values of E11; E12; E1 n; E21; E22; E2 n; E n1; E n2; ...; Э nn – A certain level of effectiveness of the decision made,

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corresponding to a specific alternative in a particular situation, describes the values of B11; B12; B1n; B21; B22; B2n; Bn1; Bn2; ...; Bnn.

Table 2. "Decision matrix" for making managerial decisions in the face of uncertainty

Decision making alternatives	Options for situations			
	C1	C2	...	Cn
A1	B11	B12	…	B1n
A2	B21	B22	…	B2n
…			…	
An	Bn1	Bn2	…	Bnn

The "decision matrix" reflects one of its types, as the "payoff matrix", as it studies the degree of effectiveness. This matrix helps to reveal the most suitable and favorable solution from the alternatives according to the selected criterion. The results of the analysis show that most decisions, which a manager has to make in the modern world, are associated with uncertainty and risk. The basis for decision-making under conditions of uncertainty is the presence of the probability of various scenarios that are unknown (Drozdov et al., 2018).

For a comparative analysis of competing alternatives, it is necessary to perform the steps presented in Figure 6.

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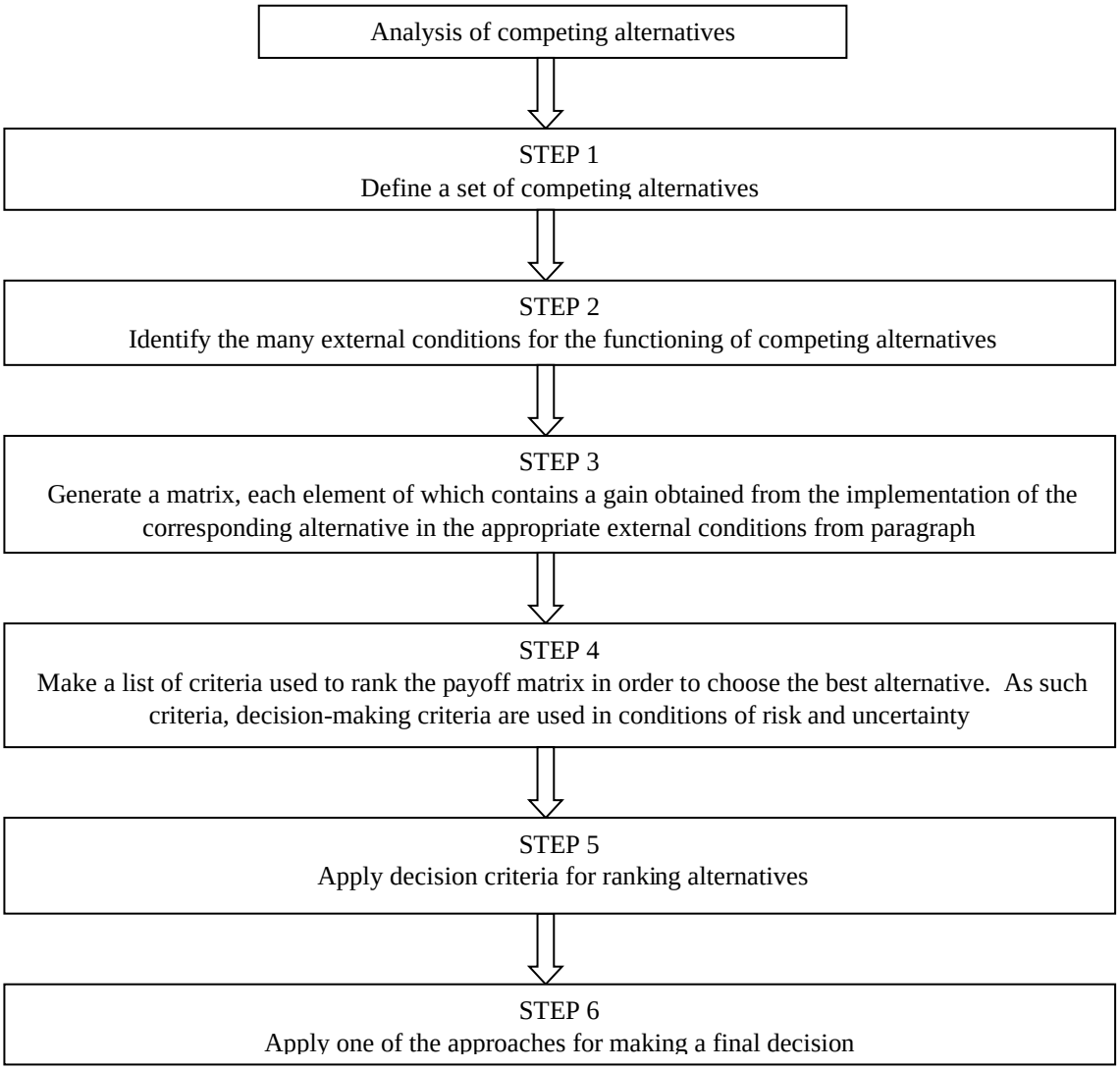

Figure 6. Stages of comparative analysis of competing alternatives

There are six main criteria for comparing alternatives in a situation of uncertainty and for calculating the best alternative solution:

1. Wald's criterion (from the possible options of the “decision matrix”, an alternative option is selected, which of all adverse outcomes of events has the largest of the minimum values, in other words, the maximum of the minimum);

2. criterion of “maximax” (minimization of the maximum possible losses);

3. Laplace criterion (the highest mathematical expectation of gain in conditions of uncertainty in the state of nature);

4. Savage criterion (one of all possible options will be chosen, that minimizes the size of the maximum losses for each decision. This method converts the “decision matrix” into a “loss matrix”, in which the efficiency values are replaced by the loss sizes for various scenarios);

5. Hurwitz criterion (the Hurwitz criterion for the coefficients of the characteristic equation of this control system allows us to conclude that the system is stable or unstable);

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6. generalized Hurwitz criterion (the generalized criterion takes into account all the outcomes of each alternative) (Tagiltseva et al., 2017).

6. Findings

Let us consider the example of management decisions used when comparing alternatives in a situation of uncertainty: the Wald criterion and the Hurwitz criterion.

According to Wald's criterion, the optimal alternative is the one that provides the best outcome among all possible alternatives under the worst of circumstances. According to Wald's criterion, the estimate of the i-alternative is its smallest gain, and the optimal alternative is the one with the maximum worst gain.

There are two projects X1 and X2, which, with three possible scenarios for the development of the region (j = 1..3), provide different profits. Profit values are shown in table 3. We must select a project for implementation**.**

Table 3. The source data

Alternatives (X_i)	State of nature (**j**)		
	1	**2**	**3**
X_1	50	45	58
X_2	44	95	47

Among the possible projects, there are no dominant ones either absolutely or by state. Therefore, the decision has to be made according to the criteria. If the optimal project is selected according to the Wald criterion, then the decision maker must perform the following actions:

1. Find the minimum outcomes for each alternative (Vald test values): $W_1 = \min(x_{1j}), j = 1..3 =>$

$$W_1 = \min(50, 45, 58) = 45$$

$$W_2 = \min(x_{2j}), j = 1..3 => W_2 = \min(44, 95, 47) = 44$$

2. Compare the values of the Wald criterion and find the largest value. An alternative with **a maximum criterion value** will be considered optimal:

$$45 > 44 => W_1 > W_2 => X^* = X_1$$

If the decision was made only by Wald's criterion, the decision maker would choose project X_1 for implementation, since the profit that this project will provide in the worst-case scenario is higher. Having chosen the optimal alternative according to the Wald criterion, the decision maker guarantees himself that in the worst case of circumstances he will not receive less than the value of the criterion.

Decision making according to the Hurwitz criterion for a decision maker – an optimist $(\lambda = 0.7)$, and a decision maker – a pessimist $(\lambda = 0.2)$ (table 3). The procedure is as follows:

1. Find the maximum $x_{i\,max}$ and minimum $x_{i\,min}$ outcomes for each project:

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$$x_{1\,max} = \max(50, 45, 58) = 58 \quad x_{1\,min} = \min(50, 45, 58) = 45$$

$$x_{2\,max} = \max(44, 95, 47) = 95 \quad x_{2\,min} = \min(44, 95, 47) = 44$$

2. Calculate the value of the Hurwitz criterion for given values of the optimism coefficient:

Optimist Decision Maker (λ=0.7):

$$H_1(0.7) = \lambda\, x_{1\,max} + (1-\lambda)\, x_{1\,min} = 0.7 \times 58 + (1-0.7) \times 45 = 54.1$$

$$H_2(0.7) = \lambda\, x_{2\,max} + (1-\lambda)\, x_{2\,min} = 0.7 \times 95 + (1-0.7) \times 44 = 79,7$$

Pessimist Decision Maker (λ=0.2):

$$H_1(0.2) = \lambda\, x_{1\,max} + (1-\lambda)\, x_{1\,min} = 0.2 \times 58 + (1-0.2) \times 45 = 47,6$$

$$H_2(0.2) = \lambda\, x_{2\,max} + (1-\lambda)\, x_{2\,min} = 0.2 \times 95 + (1-0.2) \times 44 = 54,2$$

3. Compare the obtained values. Optimal for each decision maker will be alternatives with **a maximum value** of the Hurwitz criterion:

Optimist Decision Maker (λ = 0.7):

$$54,1 < 79,7 \Rightarrow H_1(0.7) < H_2(0.7) \Rightarrow X^* = X_2$$

Pessimist Decision Maker (λ = 0.2):

$$47.6 < 54,2 \Rightarrow H_1(0.2) > H_2(0.2) \Rightarrow X^* = X_1$$

The optimal alternative under the same conditions substantially depends on the attitude of the decision maker towards risk. For a pessimist, both projects are approximately equal, and an optimist, in the hope of the best, will choose the second project. Its high best profit ***(95)*** with large values of the coefficient λ significantly increases the value of this project according to the Hurwitz criterion.

As can be seen from the analysis, the procedure for calculating the criterion is objective and does not depend on the person making decision (Tereshina & Soroka, 2014).

7. Conclusion

Thus, in conditions of uncertainty, it is very important to act thoughtfully, carefully consider various alternative solutions and assess the options for the development of the event before determining the next direction in the development strategy. The choice made will subsequently affect the result and determine the outcome: win, lose or unchanged situation.

The successful functioning of the organization without analysis of risk and uncertainty is simply impossible since any decision in the organization must pass risk control, otherwise, everything can turn out to be unpredictable consequences for the company.

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