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METHODS AND MODELS OF DECISION-MAKING IN UNCERTAIN CONDITIONS

Were considered the issues of making managerial decisions in uncertain conditions with classical criteria approach for estimation of alternatives from a set of possible decision-making variants. Was considered the decision-making model in uncertain conditions, based on the game theory concept when the uncertain situation was caused by objective circumstances which are unknown or have casual nature. Was formalized the optimal decision-making process on the conditions for adjusting the inventories use volume. Were considered the concepts and components of the information situation. Was considered the information situation classifier related to environmental uncertainty and applicable classical criteria in the decision-making process. The risk function in the implementation of a particular strategy is defined. Found risk magnitude for a possible information situation and the recorded state of the environment. Defined risk as the difference between the solution when accurate data on the environment state is available and the result when data on the state of the environment is not determined. Three-month plan creation for inventory use is taken as an example, were considered alternative strategies for the formation of inventories. Developed plan adjustment algorithm for enterprise production stocks. Defined an effective production strategy for the next strategic management of enterprise production stocks period according to the algorithm. An assessment matrix of the considered information situation is formed. According to estimates, an alternative solution was chosen. Using the voting method, the optimal strategy and the amount of risk were found. It is concluded that it is insufficient to use one classical criterion for optimal decision-making in uncertain conditions.
Keywords: model, uncertainty, criteria, decision-making, information situation.

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МЕТОДИ ТА МОДЕЛІ ПРИЙНЯТТЯ РІШЕНЬ В УМОВАХ НЕВИЗНАЧЕНОСТІ

Розглянуто задачу прийняття управлінських рішень в умовах невизначеності із застосуванням класичних критеріїв оцінки альтернатив з множини можливих варіантів прийняття рішень. Розглянуто модель прийняття рішень в умовах невизначеності, яка базується на теоретико-ігровій концепції, коли невизначеність ситуації обумовлена об'єктивними обставинами, які невідомі або носять випадковий характер. Формалізовано процес прийняття оптимальних рішень щодо умов коректування обсягів використання виробничих запасів. Розглянуто поняття та складові інформаційної ситуації. Розглянуто класифікатор інформаційних ситуацій, пов'язаних з невизначеністю середовища та класичні критерії, які можна застосувати у процесі прийняття рішень. Визначено функцію ризику при здійсненні певної стратегії. Знайдено величину ризику для певної інформаційної ситуації і зафіксованого стану середовища. Визначено, що ризик знаходиться як різниця розв'язку при наявності точних даних щодо стану середовища та результату, який може бути досягнутим, коли дані щодо стану середовища не визначені. Наведено приклад формування тримісячного плану використання виробничих запасів з врахуванням альтернативних стратегій формування виробничих запасів. Розроблено алгоритм корегування плану використання виробничих запасів підприємства. Визначено ефективну виробничу стратегію на наступний часовий період стратегічного управління виробничими запасами підприємства відповідно до алгоритму. Сформовано матрицю оцінок інформаційної ситуації, яка розглядається. Відповідно до оцінок здійснено вибір альтернативи. Застосовуючи метод голосування, знайдено оптимальну стратегію та величину ризику. Зроблено висновок про недостатність використання одного класичного критерію для раціонального вибору управлінського рішення в умовах невизначеності.
Ключові слова: модель, невизначеність, критерії, прийняття рішення, інформаційна ситуація.

Introduction

At the present development stage of the market relations with complex economic, information, and organizational relations between managing subjects, economic problems which arise in the management process of any object depend on a significant amount of external and internal factors which in different ways affect cost efficiency of enterprise functioning and quickly change in time. It is necessary to consider uncertain conditions and analyze them, to develop the corresponding models and decision-making methods under the specified conditions.

Related works

Modern decision support systems in economics and finance are based primarily on intelligent technologies. The works describe general approaches to the design of such systems [1-3] and the development of methods and models for solving specific problems of management [4], control [5] and audit [6-8], operational [9] and strategic planning [10-12]. These methods and models are relevant for objects of digital economy, which are characterized by large amounts of data in computer systems and networks [13-16]. Given the limited availability of such data, the accuracy of the methods will be insufficient, and the development of a decision support system will be ineffective. In this paper, we consider the problem of decision making under conditions of uncertainty in the absence of large amounts of data for decision making.

The purpose of the article is to research the decision-making model in uncertain conditions, based on the game theory concept with the classical criteria approach for the assessment of alternatives from a set of possible decision options under conditions of uncertainty in the absence of large amounts of data for decision making.

Methods and models of decision-making in uncertain conditions

Formalize the process of making optimal management decisions regarding the conditions for adjusting the volume of inventory use. Take the decision-making model in conditions of uncertainty static model, based on the game theory concept, when the uncertainty of the situation is due to objective circumstances that are unknown or random. [1, 2, 3, 4].

The information situation can be characterized by the set:

$$\{X, P, \overline{V}\},$$

where $X = (x_1, x_2, \dots, x_m)$ - set of decisions (alternatives) of an object of management,

$P = (p_1, p_2, \dots, p_n)$ - set of uncertain economic environment conditions,

$V_{i,j} = (v_{i,j}), i = \overline{1,n}, j = \overline{1,m}$ - the estimation functionality (estimation matrix) defined on X and P such that $V_{i,j} = f(x_i, p_j)$.

The quality of the chosen decision and its acceptance technique depend on the degree of available knowledge of the management subject. To understand a certain degree of gradation of the choice uncertainty as to the information situation (IS) and the environment states at the time of decision-making, from the point of the management subject (depending on the degree of his available information) [1]. The qualifier of the information situations connected with an uncertainty of the environment can be considered as:

I_1 – the first information situation is characterized by the set distribution of a priori probabilities on elements (factors, indicators, etc.) of environment conditions set.

I_2 – the second information situation is characterized by the set distribution of probabilities with unknown parameters or factors of the environment.

I_3– the third information situation is characterized by the system of linear ratios on elements set of a priori distribution of environment conditions.

Within the first three information situations in the uncertain conditions of the environment and consequently, risk at the implementation of the process of acceptance effective (it is desirable optimum) decisions Bayes's criteria, modular, the minimum dispersion, Germeyer, a Maximax effectively work [1, 2, 5].

I_4 – the fourth information situation is characterized by an unknown distribution of probabilities on elements (parameters, factors, etc.) of a set of conditions of the environment. For such a situation Dzheyns, Laplace's criteria work effectively.

I_5 – the fifth information situation is characterized by the opposing interests of the environment in the decision-making process by Wald's criteria, Sevidzha.

I_6 – the sixth information situation is characterized as the mean between I_1 and I_5 when choosing the environment states in the decision-making process by Gurvits's criteria, Hodge-Lehman [2].

Define functionality V , that has positive component (problem of optimization of categories of usefulness, a prize, profitability, probability of achievement of a certain strategy), that is

$$max(V_{i,j}), x_i \in X, \quad (1)$$

or

$$V^+ = V^+_{i,j}$$

let for negative component (optimization of expenses, losses, risk), that is

$$min(V_{i,j}), x_i \in X, \quad (2)$$

or

$$V^- = V^-_{i,j}.$$

Define function of risk $R = (r_{i,j}), i = \overline{1,n}, j = \overline{1,m}$ at certain strategy implementation as linear transformation is positive or negatively set functionality component V relative units of measure of components $V_{i,j}$ functionality$y \quad V$.

So, for V^+ of a certain information situation, and consequently, the recorded condition of the environment $P_j \in P$, we find risk size as

$$r_{i,j} = r_j(x_i) = l_j - V^+_{i,j},$$
$$l_j = max\, V^+_{i,j},$$

for V^- respectively

$$l_j = min\, V^-_{i,j}.$$

Define the risk as the difference between the solution when accurate data on the environment state is available and the result when data on the state of the environment is not determined.

As an example, definition of alternatives in the conditions of information situations of $I_1 - I_6$ respectively by estimates:

$$F_1\left(X^*{}_{1,opt}\right) = \underset{i}{max}\underset{j}{min}v_{ij} \text{ (Wald's criterion).} \quad (3)$$

Wald's criterion expresses the position of extreme care. This property allows to consider this criterion as fundamental one.

$$F_2\left(X^*{}_{2,opt}\right) = \underset{i}{min}\underset{j}{max}\left\{\left(max\ v_{ij}\right) - v_{ij}\right\} \text{ (Sevidzha`s criterion).} \quad (4)$$

The criterion of Sevidzha is quite often used in practical activities at making management decisions for the long period: for example, distribution of capital investments to prospect it yields good results.

$$F_3\left(X^*{}_{3,opt}\right) = \underset{i}{max}\left(\frac{1}{n}\sum_i^n v_{ij}\right) \text{ (Laplace's criterion).} \quad (5)$$

Laplace's criterion is used under a condition when probabilities of possible system conditions are unknown, that is in the conditions of complete uncertainty.

$$F_4\left(X^*{}_{4,opt}\right) = \underset{i}{max}\underset{j}{max}v_{ij} \text{ (Maksimak`s criterion);} \quad (6)$$

By the means of Maksimak`s criterion, the strategy which maximizes the maximum prizes for each information situation is defined as.

$$F_5\left(X^*{}_{5,opt}\right) = \underset{i}{max}\underset{j}{min}\left\{p_j v_{ij}\right\} \text{ (Germeyer's criterion);} \quad (7)$$

Germeyer's criterion is the criterion of extreme pessimism, considering the probability of external environment conditions.

Components $X_{i,opt}, i = \overline{1,5}$ determine volumes of resources in profit value $v_{ij} \geq 0$, or expenses $v_{ij} < 0$, and therefore, knowing the price per unit of the resources offered and expenses can be calculated volumes of profit or losses from any given strategy implementation of rather optimum alternatives. And so, achieved compliance with estimates (3) - (7) criteria $F_1 - F_5$, can be defined their quantitative estimates.

If experts cannot (or have doubts) to define a condition of the internal production stocks environment during a certain period of their use to behavior conditions of the external environment on information situations of $I_1 - I_6$, then the estimation of alternatives by all criteria is carried out $F_1 - F_5$. Definition of an optimum alternative X^*_{opt} in this case, it is carried out by a so-called method of a vote, that in essence, means choosing an alternative option for which most experts voted.

Example review. For the 3-month plan of use of production stocks (PS) creation, it is necessary to create a stock of material resources: for the first month c_1 – 2000 units, on the second c_2 – 2500 units, on the third c_3 – 3000 units. For the first month the price for 1 unit of material resources is z_1 – 5 c.u., on the second z_2 – 6 c.u., on the third z_3 – 7 at. lake. Expenses on preservation take 1 at. c.u./unit.

Can be created three alternative strategies: x_1 – to make a stock only for the first month, that is 2000 units; x_2 – to make a stock for the second month, that is 2500 units; x_3 – to make a stock in 3000 units in the first month, and other volumes if they are necessary, next month (tab. 1).

Table 1

Alternative strategy of formation of production stocks

Alternative $X = (x_1, x_2, \dots, x_m)$	Possible environment condition		
	$P_1(\mathrm{I}_1)$	$P_2(\mathrm{I}_2)$	$P_3(\mathrm{I}_5)$
x_1 - to buy 2000 units.	0	- 500	- 1000
x_2 - to buy 2500 units.	500	0	- 500
x_3 - to get 3000 units.	1000	500	0

Can be defined effective production strategy on following $t_{i+1}, i = \overline{1,k}$ period of enterprise production stocks strategic management according to the algorithm given on fig. 1.

From the statement of the problem, it is possible to formulate the following strategy: to get 2000 units of material resources; to get 2500 units of material resources; to get 3000 units of material resources.

Created the matrix of estimates:

$$v_{ij} = \begin{pmatrix} -10000 & -13000 & -13500 \\ -13000 & -12500 & -16000 \\ -16000 & -16500 & -15000 \end{pmatrix},$$

where v_{ij}, $i, j = \overline{1,3}$ determines costs of use of material resources and storage of the unused remains by a formula:

$$v_{ij} = \left[Z_0 C_i + \begin{cases} S(Ci - Cj), \text{else } Ci > Cj \\ Zj(Cj - Ci), \text{else } Ci < Cj \end{cases} \right],$$

where $Z_0 = Z_1$, S- costs of storage of the remains of material resources in conventional units on 1 to n.

According to estimates (1) – (2) we choose:

the alternative x_3 choice, since

$F_1(X_{1,opt}) = max\{min(-10000, -12500, -15000)\} = -10000$ unit;

the alternative x_1 choice, since

$F_2(X_{2,opt}) = min\{max(-20000, -30500, -40500)\} = 20000$ unit;

the alternative x_1 choice, since

$F_3(X_{3,opt}) = max\{-16000, -16500, -17500\} = -16000$ unit;

the alternative x_1 choice, since

$F_4(X_{4,opt}) = max\{max(-15000, -1600, -18000)\} = -15000$ unit.

$F_5(X_{5,opt})$ decides on the probabilities set by experts $p_1 = 0{,}2; p_2 = 0{,}5; p_3 = 0{,}3$ according to three months of stocks usage.

$F_5(X_{5,opt}) = max\{-13000, -15000, -17500)\} = -13000$ unit.

Applying a vote method, can be concluded, that optimal strategy corresponds to an alternative of X^*_{opt} = 2000 units, for which expenses on production stocks make 10000 units. Therefore, on formulas (1), (2) risks are

r =-1000 - (-16500) = 6500 units,

where in a role v_{ij} acts smallest of all from values v^+_{ij} a matrix (v_{ij}).

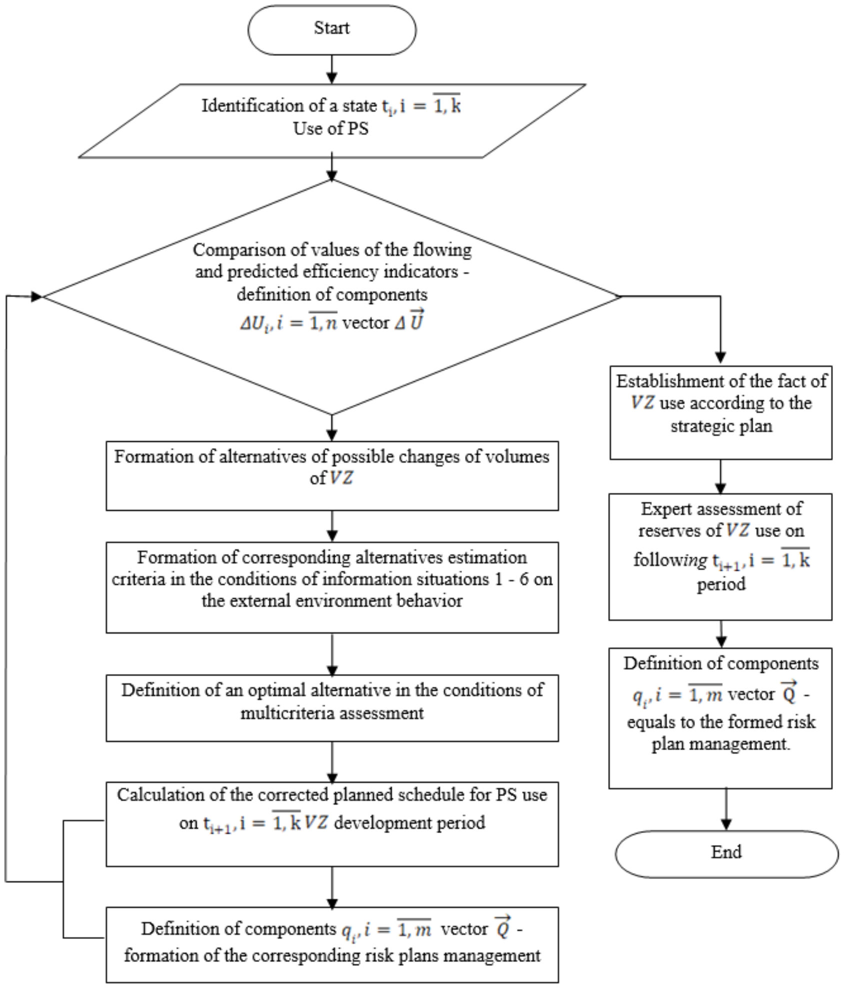

Fig. 1. Algorithm of the enterprise production stocks usage plan updating

Conclusion

Summarizing the above, we can conclude that uncertainty is an insurmountable quality of the market environment due to the influence of many different in nature and direction factors that together cannot be estimated or measured. When forming a management decision in uncertain conditions, the use of one of the above criteria is insufficient for an optimal choice of decision. It is necessary to consider the time factor, combine the criteria and analyze the criteria in situations with full data availability to verify its results reliability. It is also advisable to combine the application of these criteria with the method of expert assessments.

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