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METHODS OF RISK MANAGEMENT OF INVESTMENT PROJECTS' EXPERTISE OF MUNICIPAL INFRASTRUCTURE ENTERPRISES

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Abstract. The issue of risk assessment of investment projects at the state level is not given much attention and there is no proposed method for assessing such risks. Considering the transition of public utilities under the conditions of decentralisation to the need for self-sufficiency, the latter must use a well-established methodology for assessing risks and uncertainties, which is carried out by private sector entities expert assessments, or methods of mathematical statistics when evaluating their investment projects. A partial answer to the lack of a methodology for assessing the risk levels of investment projects should be the concept of modelling decision-making under uncertainty. The concept of modelling decision-making is based on two essential properties that constitute the very essence of the modelling process. Firstly, the model must be similar to the object under study; secondly, it must be more direct than the object under study to be considered. The main purpose of the model is the ability to conduct experiments with the model, analysis and study, which are impossible with the object under study. The paper develops the concept of modelling decision-making in conditions of uncertainty for investment projects' expertise of municipal infrastructure enterprises, the essence of which is to develop different scenarios for the business entity using the technique of modelling decision-making, taking into account different parameters and characteristics under uncertainty. Uncertainty decision-that decision-making is based on the fact that the probabilities of different scenarios for the entity making the risk decision are unknown.

Key words: decision-making, technique of modelling, municipal infrastructure enterprises, forecast, uncertainty.

JEL Classification: D81, O18, J11, D81

1. Introduction

The decision-making process is an integral part of any managerial influence. Along with information processing, decision-making becomes a key factor in determining the effectiveness of strategic planning and forecasting. At the same time, the choice of specific decisions in the framework of strategic forecasting is often closely related to risks because of the unknown specific behaviour of the initial parameters, which do not allow to determine the value of the final results of these decisions clearly.

It should also be taken into account that decision-making is the result of specific management activities, a creative process based on the principles of consistency and rationality aimed at choosing the best course of action. The task of decision-making arises when there is a goal to be achieved, there are different ways to achieve it, and there are factors that limit the ability to achieve the goal. In essence, the decision goes through the following stages (Figure 1).

Analysing the presented scheme, it should be noted that the decision-making process is cyclical, in addition, this scheme is an idealised model because due to the variety of situations and problems that need to be solved, the real decision-making processes usually differ from it, it means the actual structure of management decision-making largely determined by the situation.

At the same time, decisions made in the field of strategic forecasting should be based on data from future periods. Of course, it is physically impossible to do this, which is why it is often necessary to operate with data from past periods, as well as information about the current situation, extrapolating them over time. It turns out that the forecasting data already contain a significant share of uncertainty due to their very nature.

Depending on the degree of uncertainty of future behaviour of the initial decision-making parameters, there are risk conditions under which the probability of occurrence of individual events affecting the final result can be established with some degree of accuracy,

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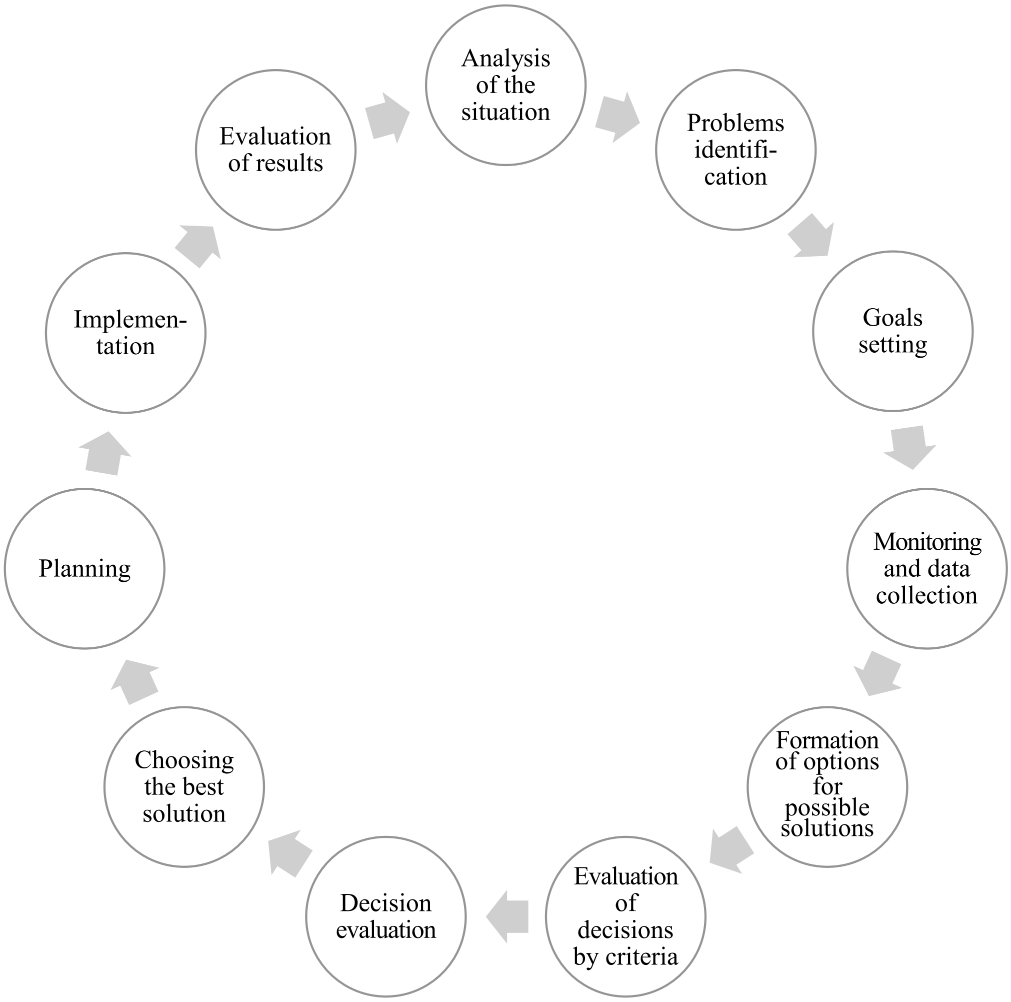

Figure 1. Stages of decision making in conditions of uncertainty

and uncertainty conditions in which such probability cannot be established.

Modelling as a method of research of control systems is used in the development of quite complex management decisions and is the construction of models of the studied object for its study. The study of object models allows to clarify the properties and characteristics of the phenomenon under study.

Like all tools and methods, the decision model can contain errors. The main reason for their occurrence is the inaccuracy of initial assumptions. Because any model is based on some initial and other assumptions, some of them can be estimated and can be objectively verified and calculated. At the same time, some preconditions are not measurable and cannot be objectively verified, in particular in the conditions of insufficient initial information. Since such assumptions are the basis of the model, the accuracy of the latter depends on the accuracy of the assumptions. The model cannot be used to forecast, for example, inventory requirements if sales forecasts for the next period are inaccurate.

In addition, there may be information uncertainty, which may be caused by either incompleteness or redundancy of the original data.

Uncertainty decision-making is based on the fact that the probabilities of different scenarios for the entity making the risk decision are unknown. In this case, choosing an alternative solution, the subject is guided, on the one hand, by the advantage of risk, and on the other hand, by the appropriate selection criteria from all alternatives in accordance with its "decision matrix".

The task of decision-making under uncertainty is the task of choosing the optimal strategy, the result of which, among other things, depends on many uncertain factors, resulting in each specific strategy (decision) corresponds not to a single outcome but many outcomes.

2. Methodology for modelling decision making under uncertainty for investment projects' expertise of municipal infrastructure enterprises

Consider the classic decision-making criteria under uncertainty (Table 1)

Table 1
Criteria for decision-making under uncertainty

Criteria	Core	Conclusions
Wald criterion	According to this criterion, playing with "nature" (external conditions, "environment") is a game with an aggressive and intelligent opponent. Choose a strategy with an index for which the position is a position of extreme pessimism. It is reinsurance for the decision maker.	Wald criterion is acceptable when the decision-making situation has the following features: – nothing is known about the possibility of implementing "nature" (external conditions, "environment") of their strategies; – it is necessary to take into account different strategies of "nature"; – the decision is unique, it can be made only once; – any risk must be eliminated.
Maximax criterion	The simplest variant of uncertainty is "benign" stochastic. In this case, the optimal strategy is the one for which the criterion reaches a maximum.	It is assumed that the decision-making situation has the following properties: – the probabilities of applying "nature" strategies are unknown and do not depend on time; – decisions are made (theoretically) infinitely many times; – for a small number of implementations, the solution involves some risk.
Savage criterion	This is also a rather pessimistic criterion, as well as the maximin criterion. However, in the case of choosing the optimal strategy, it focuses on minimal risk.	Savage criterion should be used when it is necessary to choose a strategy that will protect against excessive losses. Savage test is used when there is confidence that a possible loss will not lead to a complete collapse.
Hurwitz criterion (criterion of "optimism-pessimism" or "alpha criterion")	According to this criterion, when choosing a solution, one should not focus on pessimism or optimism. It is necessary to take a certain combination of them, setting the coefficient of optimism.	The criterion allows to take into account the level of optimism (riskiness) of the decision maker. This makes this criterion more acceptable before the maximin and maximax criteria.
Laplace criterion	This criterion makes it possible to identify the best solution in the case when none of the conditions of "nature" has a significant advantage.	The criterion should be used when each state of "nature" is equally probable compared to others. In this case, the optimal alternative is the one with the highest average score.

3. Application of the methodology for modelling decision making under uncertainty for investment projects' expertise of municipal infrastructure enterprises

We will carry out the procedure of selecting one of a number of alternative market segments to promote new services of the municipal enterprise (ME) "Odesmiskelektrotrans", which plans to purchase electric buses for use in its activities. To increase the efficiency and investment attractiveness of the company, it is advisable to develop other activities.

Based on the specifics of consumer demand, segment capacity, profitability, etc., acceptable, in addition to the main activity, are four segments (corporate services, schools and other educational institutions, rental of vehicles, excursions). It is known that when targeting each of the market segments, a number of alternative results can be realised, which differ in the size of the profit. The differences in the results are explained by different scenarios in selected target market segments.

Possible solutions (choice of a specific segment) and their consequences (results – average annual profit) are formally given in Table 2.

Table 2
Decision (win) matrix

Alternatives	Possible results				
	Y1	...	Yj	...	Ym
X1	q11	...	q1j	...	q1m
...	...	...	...	...	...
Xi	qi1	...	qij	...	qim
...	...	...	...	...	...
Xn	qn1	...	qnj	...	qnm

As follows from Table 2, each of the alternative solutions may lead to certain consequences. Many of these consequences have been identified, but which of them are realised at the time of the decision is unknown. This is the element of uncertainty and risk.

Alternatives cannot be compared by any estimate, as it is not known what result is realised. It is necessary to evaluate the whole set of values of the results for each alternative, which is generally a row of the matrix (Table 2).

After that, you can compare the alternatives for this comprehensive assessment. Thus, you can choose the best alternative not for any particular result, but for the whole set of results because it is unknown which of them will happen. We will carry out the procedure of choosing the best alternative for ME "Odesmiskelektrotrans".

We have calculated the amount of profit that the company can get from entering different segments of the transportation market; the results are presented in Table 3.

Table 3
Alternative options of the target market segment and their consequences (profit) in different conditions of the volume of traffic, thousand UAH

Market segments	Volume of traffic, thousand UAH			
	15.0	25.0	35.0	45.0
Schools and other educational institutions	72.3	93.0	95.2	102.1
Corporate services	75.5	94.0	134.0	178.4
Rental of vehicles	74.1	96.5	112.7	135.2
Excursions	83.8	87.4	99.0	97.0

Wald criterion is designed to choose from the considered options of strategies the option with the highest efficiency indicator from the minimum possible indicators for each of these options. This criterion maximises the minimum gain that can be obtained in the implementation of each of the options.

The criterion orients the decision maker to a cautious course of action aimed at generating income and minimizing possible risks at the same time. That is, it corresponds to a pessimistic type of behaviour in conditions of uncertainty.

According to Wald criterion, the preferred alternative is X *, which satisfies the conditions:
1) for the matrix of acquisitions

$$X^* = max_i min_j q_{ij}$$

2) for the loss matrix

$$X^* = min_i max_j q_{ij}$$

It is seen that the best of the worst indicators has the alternative Excursions; for it q_{ij} = 83.8
the most:

$$X^* = max_i\left(72,3; 75,5; 74,1; 83,8\right) = 83,8$$

The maximax criterion is based on the idea that the decision maker, having the opportunity to manage the situation to some extent, expects that there will be a development of the situation that is most beneficial. That is, it corresponds to a suboptimistic type of behaviour.

According to this criterion, the best of the alternatives is selected by the rules:
1) for the matrix of acquisitions

$$X^* = max_i max_j q_{ij}$$

2) for the loss matrix

$$X^* = min_i minx_j q_{ij}$$

Thus, in our variant the alternative corresponding to the maximum element of a matrix of winnings is accepted:

$$X^* = max_i\left(102,1; 178,4; 135,2; 99,0\right) = 178,4$$

Thus, the best of the best indicators has the alternative "Corporate Services", for which q_{ij} =178.4 the most.

In order to apply Savage criterion, it is necessary to construct a risk matrix. Based on the risk matrix, the best alternative would be the one that can lead to minimal losses.

The results of calculations of the risk matrix are presented in Table 4.

According to Savage criterion, the alternative "Corporate Services" is optimal, as its implementation leads to the least negative consequences.

Hurwitz criterion focuses on striking a balance between cases of extreme pessimism and extreme optimism when choosing a strategy by weighing both finals using a coefficient of optimism (confidence).

The estimate Z_I for the alternative X_i is calculated according to the rule:

$$Z_i = \alpha * max_i q_{ij} + \left(1-\alpha\right) * min_i q_{ij}$$

The coefficient of optimism (trust) α shows how much the decision maker can manage the situation and to some extent counts on a favourable outcome.

If the probabilities of favorable and unfavourable situation for the decision maker are equal, then $\alpha = 0,5$. should be taken.

At α = 1, this criterion is converted into a maximax. If we choose α close to 0, then we follow a pessimistic type of behaviour, the least risky.

The best alternative is chosen according to the following rules:
1) for the matrix of acquisitions

$$X^* = max_i Z_i,$$

2) for the loss matrix

$$X^* = min_i Z_i.$$

Since in our conditions we do not have the opportunity to rely on a certain level of optimism of the decision maker, we will take it equal to $\alpha = 0,5$.

Then:

$$Z_1 = 0,5*102,1 + 0,5*72,3 = 87,2$$

$$Z_2 = 0,5*178,4 + 0,5*75,5 = 127,0$$

$$Z_3 = 0,5*135,2 + 0,5*74,1 = 104,7$$

$$Z_4 = 0,5*99,0 + 0,5*83,8 = 91,4$$

$$X^* = max_i\left(87,2; 127,0; 104,7; 91,4\right) = 127,0$$

According to the calculations, you should choose the alternative "Corporate Services".

Laplace criterion allows you to choose the best option for management decisions, based on equal probabilities of the external environment.

According to this criterion, the best of the alternatives is selected by the rules:
1) for the matrix of acquisitions

$$X^* = max_j \bar{x} q_{ij}$$

Table 4
Risk matrix

Market segments	Profit in terms of traffic volume, thousand UAH				Risk matrix in terms of traffic volume, thousand UAH			
	15.0	25.0	35.0	45.0	15.0	25.0	35.0	45.0
Schools and other educational institutions	72.3	93.0	95.2	102.1	11.5	3.5	38.8	66.3
Corporate services	75.5	94.0	134.0	178.4	8.3	2.5	0	0
Rental of vehicles	74.1	96.5	112.7	135.2	9.7	0	21.3	43.2
Excursions	83.8	87.4	99.0	97.0	0	9.1	35.0	81.4

2) for the loss matrix

$X^* = minx_j \bar{x}q_{ij}$

Then:

$\bar{x}_1 = 1/4(72,3+93,0+95,2+102,1) = 90,7$

$\bar{x}_2 = 1/4(75,5+94,0+134,0+178,4) = 120,5$

$\bar{x}_3 = 1/4(74,1+96,5+112,7+135,2) = 104,6$

$\bar{x}_4 = 1/4(83,8+87,4,+99,0+97,0) = 91,8$

$X^* = max_i(9,7;120,5;104,6;91,8) = 120,5$

According to the calculations, the alternative is "Corporate Services", so it is advisable to choose it.

The results of the calculation of decision-making criteria allow us to conclude that the best option for ME "Odesmiskelektrotrans" is the alternative "Corporate Services", as all criteria, except the Wald criterion, showed that it is the best.

Thus, we have managed to offer the utility a balanced and sound strategic decision on the choice of alternative development.

4. Conclusions

The technique of modelling decision-making, taking into account various parameters and characteristics, in conditions of uncertainty, justifies itself and allows for qualitative analysis and strategic forecasting of the company's development. Modern approaches to forecasting development make it possible to take into account any possible options for the development of the situation, as well as to simplify the construction of a model for making sound management decisions.

The paper develops the concept of modelling decision-making in conditions of uncertainty, the essence of which is to develop different scenarios for the business entity using the technique of modelling decision-making, taking into account different parameters and characteristics in conditions of uncertainty. Uncertainty decision-making is based on the fact that the probabilities of different scenarios for the entity making the risk decision are unknown. In this case, choosing an alternative solution, the subject is guided, on the one hand, by the advantage of risk, and on the other hand, by the appropriate selection criteria from all alternatives in accordance with its "decision matrix". The task of decision-making in conditions of uncertainty is the task of choosing the optimal strategy, the result of which, among other things, depends on many uncertain factors, as a result of which each strategy (decision) corresponds not only to a single result, but many results.

Based on the calculation of decision-making criteria in conditions of uncertainty ME "Odesmiskelektrotrans" proposed a balanced and sound strategic decision on the choice of alternative development.

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