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MAKING INVESTMENT DECISIONS IN AN INDUSTRIAL ENTERPRISE UNDER UNCERTAINTY

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The article is devoted to the issue of selecting investment projects for the modernization of an industrial enterprise in the conditions of uncertainty. Uncertainty in this work is understood as the lack of data on the likelihood of the implementation of scenarios of alternative investment projects. As a methodological base, a set of generally accepted quantitative criteria for reducing uncertainty is proposed, which is characterized by different attitudes towards the probability of future events (pessimistic, optimistic, neutral, etc.). Additionally, a criterion is selected that combines expert and quantitative assessment of uncertainty. Practical calculations are made according to five criteria for three scenarios of five investment projects of an industrial enterprise. The aim of this work is to assess the difficulty of making unambiguous investment decisions under conditions of uncertainty. As a result, each of the four quantitative criteria has pointed to a different project. The fifth criterion has made it possible to limit the range of choice to two projects. This has confirmed the conclusions that making investment decisions requires the responsible person to use not only quantitative indicators, but also existing experience and intuition. The reliability of the findings has been confirmed by the use of generally accepted models and methods, as well as the practical implementation of the results. It is recommended to use these results in the scientific community when conducting subsequent methodological studies aimed at reducing uncertainty, as well as to business owners and investors when making strategic decisions.

Keywords: alternative; investment decision; investment project; criterion; uncertainty; industrial enterprise; scenario.

Introduction

In the modern world, which is characterized by ultra-fast changes, as well as instability, complexity and ambiguity, the value of the ability to work effectively under conditions of high uncertainty is increasing. Such activity requires a step-by-step study of huge amounts of information and adjustments to work with it as new data becomes available in order to be able to accurately predict the future [1, 2]. The problem of working under conditions of uncertainty is extremely relevant at the level of large industrial enterprises. Especially in situations where it is necessary to quickly solve complex economic problems, incl. selection of investment projects. The existing toolkit is rather heterogeneous and represents a combination of quantitative and expert methods. As a result, testing of such approaches is required to minimize uncertainty in the process of making investment decisions at an industrial enterprise. In the future, this will improve the tools for dealing with uncertainty and speed up the process of making effective economic decisions. This issue is extremely important for both business owners and investors. Consequently, this problem is significant not only from a scientific, but also from a practical point of view.

1. Methodology for the quantitative substantiation of investment decisions in conditions of uncertainty

The determining sign of uncertainty is the lack of sufficient information about the likelihood of future events. In particular, when making investment decisions under conditions of uncertainty, as a rule, there is not enough data on the likelihood of the implementation of investment project scenarios. In this case, the formation of the investor's personal attitude to probability is required based on a number of

criteria. The methodological basis of this work is a set of five such criteria, presented in detail below [2, 3].

Wald's criterion, based on careful decision making, is a pessimistic approach. The highest probability is assigned to the most unfavorable event among all considered projects and their corresponding scenarios, as shown in conditions:

$$\begin{cases} W_i = \min\left(X_{ij}\right), i = 1\ldots n,\ j = 1\ldots m \\ W_k = \max\left(W_i\right), i = 1\ldots n \\ X_{opt\,\mathrm{im}} = X_k, k \in (1;n) \end{cases}, \quad (1)$$

where W is Wald's criterion; n is the total number of i-th alternatives; j is the state (quantitative value) of the i-th alternative; X_{ij} is studied i-th alternative with state j; W_i is the minimum value of the state of each i-th alternative; W_k is the maximum value of the alternative state among all the minimums; $X_{optim} = X_k$ is the optimal alternative according to the criterion.

According to the optimistic "maximax" criterion, the highest probability is given to the best event in each alternative in accordance with:

$$\begin{cases} M_i = \max\left(X_{ij}\right), i = 1\ldots n,\ j = 1\ldots m \\ M_k = \max\left(M_i\right), i = 1\ldots n \\ X_{opt\,\mathrm{im}} = X_k, k \in (1;n) \end{cases}, \quad (2)$$

where M is the "maximax" criterion; M_i is maximum value of the state of each i-th alternative; M_k is the maximum value of the alternative state among all the maximums; $X_{optim} = X_k$ is the optimal alternative according to the criterion.

Laplace's criterion is based on the principle of insufficient justification and assumes that the probabilities of all alternatives should be equal to each other, and the priority is the project with the maximum average effect according to the conditions:

$$\begin{cases} L_i = \dfrac{\sum_{j=1}^{m} X_{ij}}{m}, i = 1\ldots n,\ j = 1\ldots m, \\ L_k = \max\left(L_i\right), i = 1\ldots n, \\ X_{opt\,\mathrm{im}} = X_k, k \in (1;n), \end{cases} \quad (3)$$

where L is the Laplace criterion; L_i – average result of each i-th alternative; L_k – the maximum value of the alternative state among all averages; $X_{optim} = X_k$ is the optimal alternative according to the criterion.

The Savage criterion transforms the initial data into a "regret matrix" that takes into account the lost effect and gives preference to the project with a minimum loss in (4) and (5):

$$\begin{cases} y_i = \max\left(X_{ij}\right), i = 1\ldots n,\ j = 1\ldots m \\ r_{ij} = y_i - X_{ij} \end{cases}, \quad (4)$$

where y_i is the maximum value of the state for each j-th case; r_{ij} – lost effect in the form of the difference between the maximum gain and the actual value for each state.

$$\begin{cases} S_i = \max\left(r_{ij}\right), i = 1\ldots n,\ j = 1\ldots m, \\ S_k = \min\left(S_i\right), i = 1\ldots n, \\ X_{opt\,\mathrm{im}} = X_k, k \in (1;n), \end{cases} \quad (5)$$

where S is the Savage criterion; S_i – the maximum lost payoff of each i-th alternative; S_k – the minimum lost gain among all the maximums; $X_{optim} = X_k$ is the optimal alternative according to the criterion.

The Hurwitz criterion is based on an expert's intuitive assessment of the likelihood of scenarios - the "optimism coefficient" (α). The choice of projects involves the study of only extreme scenarios according to (6) and (7):

$$\begin{cases} X_{i\max} = \max\left(X_{ij}\right), i = 1\ldots n,\ j = 1\ldots m \\ X_{i\min} = \min\left(X_{ij}\right), i = 1\ldots n,\ j = 1\ldots m \end{cases}, \quad (6)$$

where $X_{i\max}$ is the maximum state value for each i-th alternative; $X_{i\min}$ is the minimum state value for each i-th alternative.

$$\begin{cases} H_i = \alpha \cdot X_{\max} + (1-\alpha) \cdot X_{\min}, i = 1\ldots n,\ j = 1\ldots m, \\ H_k = \max\left(H_i\right), i = 1\ldots n, \\ X_{opt\max} = X_k, k \in (1;n), \end{cases} \quad (7)$$

where H is the Hurwitz criterion; H_i - the value of the gain, taking into account the "optimism coefficient" α for each i-th alternative; H_k – the maximum payout among all alternatives; $X_{optim} = X_k$ is the optimal alternative according to the criterion.

2. Practical choice of investment projects in conditions of uncertainty.

The scenario conditions of investment projects for the modernization of an industrial enterprise are presented in Table 1, and the results of the assessment of the criteria are in Table 2.

Table 1

Brief description of projects

Alternative projects	Profit / Loss Scenarios (RUB thousand)		
	Pessimistic	Neutral	Optimistic
Project 1	–1 000	–100	3 000
Project 2	0	10	2 000
Project 3	100	300	1 000
Project 4	–500	0	2 500
Project 5	0	200	1 500

Table 2

Criterion values for projects

Alternative projects	Selection of projects (criteria)	Criterion value, thousand rubles
Project 1	"Maximax" / Hurwitz	M_1 = *max* (–1000; –100; 3000) = 3000 At α = 0,8 H_1 = 0,8·3000 + 0,2·(–1000) = 2200
Project 2	Laplace / Hurwitz	$L_2 = \frac{0+10+2000}{3} = 670$ At α = 0,3 H_2 = 0,3·2000 + 0,7·0 = 600
Project 3	Wald	W_3 = *min* (100; 300; 1000) = 100
Project 4	Savage	S_4 = *max* (600; 300; 500) = 600
Project 5	–	

Calculations showed that the opinions of the most objective indicators (with the exception of the intuitive Hurwitz criterion) were divided between the first, second, third and fourth projects. When taking into account the expert assessment according to the Hurwitz criterion, the first and second projects become priority. The fifth project was not selected by any of the criteria, although it is among the break-even ones.

Conclusions

1. A method is proposed for solving the urgent problem of selecting investment projects in conditions of complete uncertainty.

2. A comparative analysis of alternative projects and their scenarios was carried out according to five criteria for reducing uncertainty.

3. The obtained results are recommended to be used when developing an approach to reducing uncertainty and making investment decisions at industrial enterprises.

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ПРИНЯТИЕ ИНВЕСТИЦИОННЫХ РЕШЕНИЙ НА ПРОМЫШЛЕННОМ ПРЕДПРИЯТИИ В УСЛОВИЯХ НЕОПРЕДЕЛЕННОСТИ

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Статья посвящена вопросу отбора инвестиционных проектов модернизации промышленного предприятия в условиях неопределенности. Под неопределенностью в работе понимается отсутствие данных о вероятности реализации сценариев альтернативных инвестиционных проектов. В качестве методической базы предложен набор общепризнанных количественных критериев сни-

жения неопределенности, характеризующихся различным отношением к вероятности будущих событий (пессимистичное, оптимистичное, нейтральное и др.). Дополнительно выбран критерий, сочетающий экспертную и количественную оценку неопределенности. Практические расчеты произведены по пяти критериям для трех сценариев пяти инвестиционных проектов промышленного предприятия. Целью работы является оценка сложности принятия однозначных инвестиционных решений в условиях неопределенности. В результате, каждый из четырех количественных критериев указал на свой проект. Пятый критерий позволил ограничить круг выбора до двух проектов. Это подтвердило выводы о том, что принятие инвестиционных решений требует от ответственного лица использования не только количественных показателей, но и имеющегося опыта и интуиции. Достоверность полученных выводов подтверждена применением общепризнанных моделей и методов, а также практической реализацией полученных результатов. Данные результаты рекомендуется использовать в научном сообществе при проведении последующих методических исследований, направленных на снижение неопределенности, а также собственникам бизнеса и инвесторам при принятии стратегических решений.

Ключевые слова: альтернатива; инвестиционное решение; инвестиционный проект; критерий; неопределенность; промышленное предприятие; сценарий.

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