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METHODS OF MAKING MANAGEMENT DECISIONS UNDER CONDITIONS OF UNCERTAINTY
МЕТОДИ УХВАЛЕННЯ УПРАВЛІНСЬКИХ РІШЕНЬ В УМОВАХ НЕВИЗНАЧЕНОСТІ

Summary. *Introduction. The process of making managerial decisions under conditions of uncertainty is one of the most challenging tasks of modern management. Limited information, the likelihood of unpredictable changes and the need to take into account many factors make it difficult to choose the best solution. In such conditions, traditional methods may not be effective enough, which necessitates the use of approaches aimed at evaluating alternatives, predicting possible consequences and minimizing risks.*

Objective. The purpose of the article is to study the methods of managerial decision-making under conditions of uncertainty, to assess their effectiveness and to analyze the factors affecting the efficiency of this process.

Materials and methods. The study uses the methods of systematic and comparative analysis and structuring of approaches to managerial decision-making. The study is based on the analysis of scientific papers covering methods of decision-making under uncertainty.

Results. The study showed that modern approaches to management decision-making can be divided into analytical, algorithmic, econometric and digital methods. Analytical approaches are based on mathematical models and statistical analysis. Algorithmic methods, such as regression analysis, simulation modelling and machine learning-based forecasting, help to improve the accuracy of risk assessment. Econometric methods ensure that the impact of various factors on management decisions is taken into account, and digital technologies allow for automated analysis of large amounts of data. The study results confirm that the use of digital technologies, such as artificial intelligence and decision support information systems, helps to improve the validity of management decisions and minimise the impact of the human factor.

Prospects. Further research could be aimed at improving methods for evaluating management decisions under conditions of uncertainty, developing integrated forecasting models and automating decision-making processes, which would increase their validity.

Key words: *management decision-making, uncertainty, analytical methods, algorithmic analysis, forecasting, simulation modeling, digital technologies, information systems, artificial intelligence, risk assessment.*

Анотація. *Вступ. Процес ухвалення управлінських рішень в умовах невизначеності є одним із найбільш складних завдань сучасного менеджменту. Обмеженість інформації, ймовірність непередбачуваних змін та необхідність врахування багатьох факторів ускладнюють вибір оптимального управлінського рішення. У таких умовах традиційні методи можуть виявитися недостатньо ефективними, що зумовлює потребу у використанні підходів, спрямованих на оцінку альтернатив, прогнозування можливих наслідків та мінімізацію ризиків.*

Мета. Метою статті є дослідження методів ухвалення управлінських рішень в умовах невизначеності, оцінка їхньої

результативності та аналіз чинників, що впливають на ефективність цього процесу.

Матеріали і методи. У процесі дослідження використано методи **системного і порівняльного аналізу** та **структуризації** підходів до ухвалення управлінських рішень. Дослідження ґрунтується на аналізі наукових праць, що висвітлюють методи ухвалення рішень в умовах невизначеності.

Результати. Дослідження показало, що сучасні підходи до ухвалення управлінських рішень можуть бути розділені на аналітичні, алгоритмічні, економетричні та цифрові методи. Аналітичні підходи базуються на математичних моделях та статистичному аналізі. Алгоритмічні методи, зокрема регресійний аналіз, імітаційне моделювання та прогнозування на основі машинного навчання, дозволяють підвищити точність оцінки ризиків. Економетричні методи забезпечують врахування впливу різних чинників на управлінські рішення, а цифрові технології дозволяють здійснювати автоматизований аналіз великих обсягів даних. Результати дослідження підтверджують, що використання цифрових технологій, таких як штучний інтелект та інформаційні системи підтримки ухвалення рішень, сприяє покращенню обґрунтованості управлінських рішень і мінімізації впливу людського фактора.

Перспективи. Подальші дослідження можуть бути спрямовані на вдосконалення методів оцінки управлінських рішень в умовах невизначеності, розробку інтегрованих моделей прогнозування та автоматизацію процесів ухвалення рішень, що дозволить підвищити їхню обґрунтованість.

Ключові слова: ухвалення управлінських рішень, невизначеність, аналітичні методи, алгоритмічний аналіз, прогнозування, імітаційне моделювання, цифрові технології, інформаційні системи, штучний інтелект, оцінка ризиків.

Problem statement. The process of making managerial decisions under uncertainty is a complex task that requires a comprehensive analysis of options, assessment of possible consequences and consideration of risks. The use of traditional decision-making methods does not always allow to obtain sufficiently reasonable results, since such methods often do not take into account variable factors that affect the results of management actions.

The development of mathematical methods, algorithmic analysis and digital technologies opens up new opportunities for evaluating management decisions. In particular, the use of forecasting methods, simulation modeling, and decision support information systems allows to obtain more accurate results, minimize the influence of subjective factors, and increase the validity of decisions. However, the choice of an appropriate approach to decision-making depends on many factors, such as the level of uncertainty, availability of data for analysis, the ability to use digital technologies, and the speed of information processing.

Despite the active implementation of modern analysis methods, the following issues remain insufficiently researched

- lassification and evaluation of methods used to make management decisions under conditions of uncertainty;

- factors influencing the effectiveness of management decision-making;

- possibilities of using mathematical, algorithmic and digital methods to evaluate decision options;

- approaches to improving the validity of decisions made using information technology.

In view of this, there is a need for a comprehensive study of approaches to management decision-making, analysis of their methods of evaluation and implementation, as well as studying the impact of digital technologies on the effectiveness of this process.

Analysis of recent research and publications. Scientific achievements

in the field of management decision-making under conditions of uncertainty are based on the use of modern mathematical, algorithmic and information methods. The work of Oleshko T., Popyk N., Domaskina K. studies the levels of uncertainty, as well as the features of management decision-making depending on the environment [3].

Researchers Tyrkalo Y. [12], Begun S. [6] and Korem N., Duek O., Jia R., Wertheimer E., Metviner S., Grubb M., Levy I. [2] focus on the use of algorithmic and probabilistic models that allow objective assessment of decision options and consider forecasting methods based on machine learning, multivariate analysis and probabilistic distributions that ensure the accuracy of risk assessment.

Considerable attention is paid to the role of information technology in management decision-making. The article by Shuba T., Lyashevska V., Hlebova N., Kozarenko L., Popovych A. presents the results of research on assessing the effectiveness of analytical tools to reduce uncertainty in the management process [13]. A similar approach is applied in the studies of Develaki M., who identifies the areas of use of digital technologies to justify management decisions [1] and Doronina O. and Dyadiy V. [7], who identify the areas of use of artificial intelligence for making management decisions, as well as outline the benefits and risks of its application.

The peculiarities of decision-making in the field of economic sustainability of business entities are studied in the work of Panchenko V., Panchenko O. [10], which defines the principles and criteria for making managerial decisions in conditions of critical instability.

Researchers Popil Y., Khomyuk N., Korobchuk M. in their work [11] considered the role of situational management in the process of making management decisions, in particular, how this approach allows to quickly adapt management processes to changes in the market environment.

Considerable attention is paid to simulation modeling methods for

decision-making in the IT sector. The study of Koshova O., Olkhovska O., Brazhnichenko A. considers the advantages and limitations of using simulation modeling to optimize resources and predict the consequences of management decisions [8].

In addition, the article by Levina-Kostiuk M., Melnychuk O., Telichko N. [9] considers the classification of decision-making methods by the degree of available information, and characterizes the methods of game theory, statistical solutions and expert methods for use in conditions of limited information.

The analysis of scientific papers leads to the conclusion that modern approaches to managerial decision-making under conditions of uncertainty are based on the use of mathematical, algorithmic and digital methods that provide for the assessment of decision options, forecasting their consequences and increasing the validity of managerial actions. At the same time, the issue of a comprehensive study of the factors influencing the choice of decisions in unstable conditions, as well as the development of universal approaches to their evaluation and implementation, remains open, which necessitates further research into the possibilities of integrating analytical tools and modern information technologies into the management decision-making process, which is the subject of this study.

Formulation of the objectives of the article (task statement). The purpose of the article is to study approaches to managerial decision-making under conditions of uncertainty, to determine the methods of their evaluation and implementation, and to analyze the factors affecting the efficiency of this process.

To achieve this goal, the following tasks have been identified:

- to characterize the methods used to make management decisions under conditions of uncertainty;

- to identify the factors that influence the choice of management decisions;

- to analyze the possibilities of applying mathematical, algorithmic and digital methods to evaluate decision options;

- to consider approaches to improving the validity of decisions made using modern information technologies.

Summary of the main research material. The process of making managerial decisions under uncertainty involves the use of various methods for evaluating options and predicting consequences. Researchers [1-6, 12] identify several approaches used in modern management practice:

- analytical methods that involve the use of mathematical models to evaluate alternative options;

- algorithmic methods, including regression analysis, simulation modeling, and machine learning-based forecasting;

- econometric approaches that allow assessing the impact of various factors on decision-making and modeling their consequences;

- digital technologies that involve the use of information systems, artificial intelligence and big data analysis.

Different approaches to management decision-making under conditions of uncertainty have their advantages and limitations, which determines the need for their careful analysis before using them in management practice (Table 1).

Management decisions are often made with limited information, which makes it difficult to choose the most appropriate option. In this regard, digital technologies are becoming increasingly widespread. The use of decision support information systems allows analyzing large amounts of data, predicting possible scenarios and determining optimal management actions [13].

Table 1

Comparison of the main methods of management decision-making under uncertainty

Method	Main characteristics	Scope of application	Advantages	Limitations
Analytical methods	Use of mathematical models and analysis methods to substantiate management decisions	Financial analysis, risk management, strategic planning	High forecasting accuracy, possibility of in-depth analysis of factors	Requires a significant amount of data and computing resources
Algorithmic methods	Automated calculation of optimal options based on mathematical algorithms	Logistics, resource management, operational management	High speed of information processing, possibility of automation	Sensitivity to the quality of source data, complexity of algorithm settings
Econometric approaches	Use of statistical and regression models for forecasting variables	Market analysis, macroeconomic research, investment management	Taking into account the interrelationships between variables, use in long-term forecasting	High dependence on the accuracy of the source data, difficulty in interpreting the results
Digital technologies	Use of artificial intelligence, machine learning, and big data in decision-making	Automated decision support systems, production process management, financial sector	High speed of analysis, ability to forecast based on retrospective data	Requirement of large computing resources, risks associated with data security

Source: own research

One of the directions of digital systems development is the integration of artificial intelligence methods. Such approaches allow:

- automate the analysis of alternatives;

- reduce the influence of the human factor

- improve the accuracy of predicting the consequences of management decisions.

Modern digital technologies play an important role in the management decision-making process by automating data analysis, identifying patterns, and forecasting possible scenarios. The use of such tools helps to improve the accuracy of decisions, reduce uncertainty and minimize possible risks [1].

One of the advantages of digital technologies is the ability to process large amounts of data in real time, which allows you to quickly respond to changes in the environment and choose the most optimal solutions. The study identified the main types of digital technologies used in management decision-making, their functions and examples of use (Table 2).

Table 2

The role of digital technologies in management decision-making

Technology	*Main function*	*Example of use*	*Advantages*	*Limitations*
Artificial intelligence	Automated big data analysis, scenario forecasting, process optimization	Optimization of logistics operations, production cycle management	High speed of analysis, detection of hidden patterns, self-learning capability	High implementation cost, need for large volumes of high-quality data
Machine learning	Identification of relationships between data, building predictive models	Financial risk analysis, recognition of fraudulent transactions in the banking sector	Automatic model adjustment, improving forecast accuracy	Dependence on retrospective data, difficulty in interpreting results
Simulation modeling	Prediction of system behavior, assessment of the consequences of various management decisions	Calculation of the efficiency of production processes, testing of strategic changes in enterprises	Minimization of risks before implementing changes, the ability to test various scenarios	High dependence on the accuracy of the initial parameters, high computational complexity
Decision support systems (DSS)	Automated evaluation of alternatives, preparation of recommendations for management decision-making	Choosing the strategic direction of the company's development, personnel management	Optimization of decision-making process, increase of efficiency of management processes	Requires constant data updating, possible errors in case of changes in external conditions

Source: own research

The table shows that digital technologies are making management decision-making more structured, accurate, and predictable. Artificial intelligence and machine learning provide analysis of large amounts of information and automate decision-making, which is especially useful in the financial sector, logistics, and production management. At the same time, their implementation requires significant resources and careful data quality control.

Simulation modeling allows you to assess the effectiveness of various

management decision options before they are implemented, which helps minimize possible risks. However, its use requires accurate input parameters, as errors in the data can lead to incorrect forecasts.

Decision support systems provide managers with analytical information to choose the best course of action. Their advantage is the speed of information processing and integration with other digital platforms. However, to remain relevant, they require constant updating of databases.

Thus, digital technologies significantly improve the efficiency of the management decision-making process, reduce uncertainty and allow for a greater number of factors to be taken into account. However, their implementation requires significant resources, data control, and an understanding of the limitations of each method.

Research confirms that the use of analytical methods, algorithmic analysis, and digital technologies helps to increase the validity of management decisions. At the same time, there is a need to develop comprehensive approaches that combine several methods to more accurately predict the consequences and make informed choices [3].

The analysis of the implemented management methods shows that the use of modern analysis tools allows us to:

- reduce decision-making time,

- improve accuracy through the use of algorithmic models and machine learning;

- reduce the level of uncertainty by analyzing large amounts of data and assessing possible scenarios for further developments.

Despite the positive impact of digital technologies on the decision-making process, their use is associated with a number of limitations that must be taken into account when choosing analysis and forecasting methods. The main factors affecting the efficiency of digital technologies are:

- quality of input data - the accuracy of forecasting models and

algorithmic analysis depends on the availability of reliable and representative data, and insufficient or inaccurate information can lead to errors in management decision-making;

- integration of digital systems - for the effective use of information and analytical tools, their interaction with existing management systems is necessary, which requires additional resources and specialized knowledge;

- resource-intensive technologies - the use of artificial intelligence, machine learning and other algorithmic models requires significant computing power, which can be financially costly for enterprises;

- updating analysis methods - digital technologies are developing rapidly, so methods that are effective today may need to be improved in the future.

In view of the above, an important area of research is the development of decision-making systems that use artificial intelligence and analytical models to optimize management processes and adjust algorithms based on updated data and changes in external factors.

Conclusions and prospects for further research. An analysis of modern approaches to management decision-making under conditions of uncertainty shows the effectiveness of methods that combine mathematical modeling, analytical algorithms, and digital technologies. Their use helps to increase the accuracy of decisions, minimize possible risks, and improve the validity of management action options.

At the same time, improving these approaches requires the creation of universal models that allow the integration of several analysis methods into a single system. Therefore, further research in the field of management decision-making should be aimed at developing effective analysis models that provide accurate forecasting of the consequences of decisions and minimize risks under conditions of uncertainty.

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