

MANAGING UNCERTAINTY: THE ROLE OF PROBABILISTIC MODELS IN ENHANCING DECISION ACCURACY AND EFFICIENCY

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Abstract: The trend of economic process dynamics in the face of instability requires new concepts for implementing the management paradigm. This article aims to analyse the impact of probabilistic models on the accuracy and efficiency of management in conditions of uncertainty. The study applied general scientific methods: analysis, synthesis, generalisation, specification, induction, deduction, and abstraction. During the study, the authors investigated the main aspects of forming a management strategy in times of uncertainty. They analysed the relevance of a systematic approach to business continuity management in adverse conditions. The article highlighted the primary strategy of crisis management in times of uncertainty. The authors have considered the specifics of modern models for levelling the impact of instability. The paper also substantiated the potential for improving the crisis management mechanism in today's unpredictable multifactorial conditions of economic activity. The authors have demonstrated the effectiveness of applying probabilistic models in terms of accuracy and efficiency of management in conditions of uncertainty under the influence of a complex of probabilistic external and internal factors. The article identified the need to improve the mechanism of the effective management system based on probabilistic models during periods of instability. The authors have proposed a model of an anti-crisis strategy for unforeseen conditions, specified local techniques, and a mechanism for its implementation tactics. It is a mutually consistent synergistic system of strategy, methodological support, and practical tools. Furthermore, the practical value of research findings is seen in the possibility of their application when developing or optimising anti-crisis strategies for managing economic activity in the face of uncertainty.

Keywords: Probabilistic nature, Crisis management, Principle of economic feasibility, Risk management, Effective development, State regulatory policy, Civil service, Public administration innovation.

1 Introduction

Developing and selecting optimal management solutions is considered a top issue in researching and modelling complex economic systems. The situation becomes particularly challenging in the face of uncertainty. Limited operational information on the dynamics of economic processes, deterministic crisis phenomena in society and economic activity, the inability to fully formalise them, the multivariance of behavioural reactions of business entities, multicriteria, and an increased level of conflict cause uncertainty over the development of economic phenomena.

Many relevant studies are devoted to the issues of forming and improving management strategies under conditions of instability. Some modern scholars (Levenchuk et al., 2021; Izmailova et al., 2022) study the peculiarities of transforming the management paradigm in the context of global digitalisation. This significantly changes approaches to modelling management decisions. Several scholars (Yankovska et al., 2023; Shchetinina et al., 2021) reflect on the issues of forming company's management strategy to prevent the impact of uncertainty factor in economic activity. Other researchers (Kataieva et al., 2020; Kotsyuba, 2022) note that in times of uncertainty, research on modelling mechanisms becomes extremely important in terms of the impact on the accuracy and efficiency of management.

The general issues of uncertainty of economic conditions and processes that necessitate the development of appropriate management strategies to overcome them are thoroughly studied in the papers of some contemporary scholars (Harmatiy, 2023). Specific issues related to the transformation of the modelling

functionality as a specific tool in economic management systems are reflected in the studies of leading researchers in this field (Levenchuk & Bidyuk, 2020; Koval, 2022). At the same time, according to scholars, the very concept of crisis management is constantly and continuously evolving following the dynamics of external and internal influence factors. It forms the conditions for the effective development of business competitiveness (Halakhova & Kulyk, 2023). According to scientists, public administration science's practical orientation should manifest in an adequate state regulatory policy.

However, scholars have addressed the issue of optimising the management paradigm in the era of economic process uncertainty by applying probabilistic modelling on a selective basis. This relatively new and dynamic concept needs more study and further scientific consideration. Additional attention should also be paid to the development of practical algorithms for formulating appropriate management strategies to offset the impact of instability in the factorisation of influence on the accuracy and efficiency of management decision-making. This article aims to analytically substantiate the impact of probabilistic models on making effective decisions within the management mechanism for overcoming the influence of unforeseen conditions.

2 Literature review

The studies of Ukrainian and foreign scholars form the theoretical and methodological background for developing approaches to management in conditions of uncertainty. Many experts pay attention to the issue of modelling capabilities being involved in the management process in the face of uncertainty and crisis phenomena.

The issues of developing an anti-crisis management paradigm in unstable economic, social, and political conditions have gained significant relevance in the modern scientific community. Most of the studies performed by Ukrainian scholars (Huskova, 2020; Zheldak et al., 2020) are devoted mainly to the methodological and technical aspects of implementing management processes in the face of uncertainty, as well as to the classification of its mechanisms and description of tools. At the same time, the scientific achievements of foreign authors (Boomen et al., 2020; Hensel et al., 2022) are primarily relevant. They offer a comprehensive practical approach involving the capabilities of the modelling process. They cover aspects of analytics and evaluation from the standpoint of maintaining the efficiency of economic activity under conditions of uncertainty. Such processes should occur against active state and administrative innovation activities.

By considering the role of management systems in modern management strategies, many scholars (Zuluaga & Sánchez-Silva, 2020) have shown the power and multifactorial impact of the targeted modelling tools on the stabilisation of business processes and the positioning of companies in the market in terms of accuracy and efficiency of decision-making. The authors (Sun & Ding, 2020) emphasise the relevance of taking into account risk growth in the context of instability not only for the efficiency and effectiveness of economic processes but also for the stability of their implementation, i.e., the factor of their continuity.

Some researchers (Caunhye et al., 2022) analyse the successful experience of modelling management decision-making in crisis conditions and instability of economic systems. The publications of some scholars (Dehshiri et al., 2023) track the idea that modern management strategies in the face of uncertainty provide maximum opportunities for effective involvement of existing potential, while possessing the functionality of preventive protection against negative consequences.

According to some researchers (Pellegrino et al., 2021), the consequences of the global transformation of economic processes have accelerated transformational changes. Nowadays, market participants who ignore the possibilities of modelling the functionality of management decisions are at risk of losing a significant set of opportunities. Some authors (Peñalba-Aguirrezabalaga et al., 2020) have also thoroughly analysed approaches to forming accurate and effective management decisions in the face of external and internal factors instability.

However, without offsetting the scientific importance of contemporary scholars' achievements, it is necessary to note the relevance of the practical implementation of probabilistic modelling tools in practical management strategies to optimise the accuracy and efficiency of management decision-making. There are still several issues regarding forming a universal concept of strategic management in the face of uncertainty. This concept would be able to respond promptly to dynamic market changes. Such circumstances necessitate further scientific research and their deepening and detailing.

3 Materials and methods

This study's methodological framework was based on several general scientific and unique methods of cognition, particularly abstract and logical, functional and structural analysis, synthesis, generalisation, specification, induction, deduction, and theoretical modelling.

The study used a comprehensive systematic approach, which allowed us to study the research object as a system with interconnections and interdependencies.

Various analysis and synthesis methods were used to identify the development factors of the object under study, its defining functional elements, and the transformational capabilities of modern management strategies. The induction method was used during the predictive analysis of the expected effectiveness of probabilistic modelling in terms of accuracy and efficiency of management decisions. We have formed the management paradigm integrity conceptual framework through abstraction as a structural and consequential system of interrelations. The generalisation method was applied at the stage of forming priority directions for optimisation of the management paradigm, including the possibilities of probabilistic modelling in the face of uncertainty and crises.

4 Results

The management paradigm in conditions of uncertainty is currently viewed as a modern management concept aimed at ensuring the effectiveness of economic activity in the era of critical socio-economic phenomena and social environment instability. This approach involves the development of specific technologies and tools that consider both the crisis's problems in terms of management and the opportunities stimulated by it. At the same time, anti-crisis management strategies are based on short-term and long-term solutions aimed primarily at accurate and effective management in conditions of uncertainty. Today, the civil service should be viewed in the context of public administration innovation, which will improve management processes in the economic sector and optimise practical anti-crisis strategies of national and local importance.

Applying the probabilistic modelling approach to the current state of economic development is inherent in considering the complex functioning conditions in the face of uncertainty. These conditions are formed under the influence of challenges and threats. In addition, the role of some of them is gradually intensifying, which requires considering the synergistic impact of their combination. Applying the probabilistic modelling approach within the management system can significantly affect the accuracy and efficiency of management processes in the face of uncertainty.

The analysis of the fundamental trends in updating approaches to ensuring sustainable economic activity in the context of

instability of socio-economic and socio-political processes allows us to assert that, as of today, there is a general tendency of vectoring towards an integrated methodology as the most effective one, taking into account the specifics of management issues in the context of their formation during times of uncertainty.

Potential threats to the sustainability of economic activity have a pronounced probabilistic nature. Therefore, the description of such systems can be based on the postulates of the theory of random processes. Several well-known linearisation methods can be used to select the most acceptable and effective management decisions. The latter can significantly simplify the algorithm of system dynamics analysis.

When forming and improving a management system in an unstable environment, updating the complex of external and internal influencing factors is necessary. This serves as a prerequisite for individually implementing independent analytics for each significant random factor.

In conditions of uncertainty, modelling is seen as a prioritised systematic scientific-practical tool for forecasting, identifying potential consequences of alternative management decisions, and selecting the most optimal ones. The management paradigm deems it necessary to develop the appropriate procedural functionality for making strategic decisions to ensure the rationality of forming non-programmed management concepts.

The initial stage of researching the prerequisites for possible further justification of probabilistic modelling requires comprehensive analysis. The presence of sufficient time resources and the necessary volume of relevant information are the fundamental indicators for selecting the method of forming management decisions based on probabilistic modelling. At the same time, a significant functionality belongs to public administration innovation activity, which has the features of adaptability, flexibility, and openness to the latest opportunities.

Among the main components of the model in terms of formalising the management situation are:

- the descriptive performance of potential alternative decisions;
- identification of the target functionality;
- the formation of an individualised system of constraints.

Solving the developed probabilistic model involves applying mathematical tools, the choice of which is determined by the type and complexity level of the model being studied.

For the practical application of the results of probabilistic modelling, it is necessary to control the model and identify the degree of its correspondence to the actual conditions of economic activity. Even in the case of positive experience with the proposed probabilistic model in the past, its current version mostly requires optimisation due to the dynamics of the operating environment. Based on the probabilistic modelling results, the possibility of selecting the most optimal alternative is formed.

At the current development level of digitalised mathematical functionality, solving linear processes during probabilistic modeling is considered an accessible target tool. After all, approximation methods or similar mathematical tools can be used in case of difficulties obtaining accurate analytical solutions.

It is worth noting that the primary stage in forming a management system in the face of uncertainty includes analysing the identified factors and their impact on the processes critical for economic functioning. Considering these factors, it seems necessary to prioritise the identification of potential threats under conditions of uncertainty. State regulatory activity in a crisis environment of uncertainty should ensure the stability of the

essential components of the management system, which will guarantee its sustainability.

The methodological technique of probabilistic modelling is based on implementing computer algorithms for forming strategic economic development and identifying the specifics of possible consequences of negative impacts. The methodology of individualised development of a simulation probabilistic modelling algorithm is often used to implement the idea of building probabilistic models. This creates the precondition for implementing an experimental study using digital technologies and economic and mathematical modelling tools. In general, the probabilistic modelling process can be represented as an algorithm that allows the formation of a practical probabilistic model step by step (Figure 1).

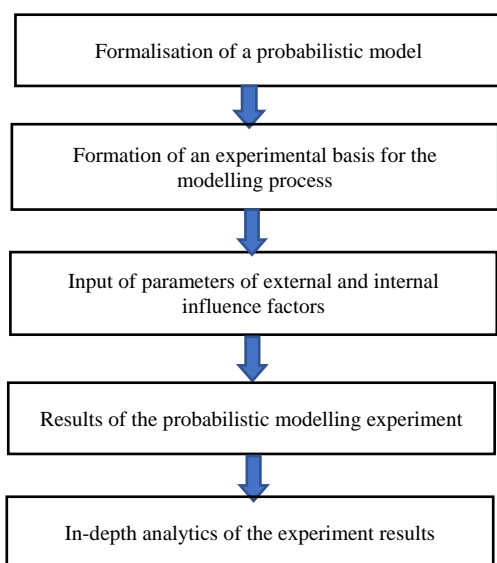


Figure 1. The standard algorithm for implementing probabilistic modelling

Source: author's elaboration based on (Levenchuk et al., 2021)

After analysing Figure 1, it should be noted that the probabilistic model should synergise individual parameters of economic activity. This lets us formally describe the model factors (quantitative indicators of variables' distribution).

According to research results' analytics, economic processes in the face of uncertainty are most effectively described by a normal distribution and fixed values of individual model parameters.

An in-depth analysis of the simulation results is essential in building a probabilistic model. The latter is realised by estimating the probability of the indicator value falling into a specific interval and the possibility of obtaining a particular result with a certain probability. The proposed toolkit can be effectively used to develop a crisis management programme under conditions of uncertainty, to formulate accurate and effective decisions, and to evaluate the effectiveness of the strategic management paradigm. In this context, public administration innovation involves using public authorities' direct administrative and indirect regulatory influence on the relevant management objects. The first group includes legal regulation, persuasion, and coercion methods, while the second group includes education, incentives, democratisation of governance, placement of public orders, and manipulation.

Probabilistic modelling of the decision-making process in an unstable socio-economic environment makes it possible to implement quantitative assessments and quantitative analysis of management decision results. The proposed concept allows the quantification of managerial situations, bringing the decision-making process to a qualitatively new level of accuracy and efficiency. The professional use of probabilistic models of the

decision-making process allows for controlling intuitive reasoning within the management system. It guarantees a high degree of consistency, coherence, and reliability of the management decisions. At the same time, these models create the prerequisites for maximising the potential of intuition in convergence with experience.

The alternative variations of management decisions obtained through probabilistic modelling have a recommendation functionality. They stimulate the adoption of an accurate and effective management concept. Nevertheless, if the potential of their use in complex situations of uncertainty is ignored, the management system's efficiency is significantly reduced. It should be noted that a decision obtained using probabilistic modelling of a situation requires mandatory analytics and performance monitoring.

5 Discussion

The transformation of the market participant's management system in the face of uncertainty requires dynamic approaches to forming management decisions. According to scholars (Moen et al., 2023), it is based on effectively adapting the market object's activities to the conditions of economic instability.

Packard and Clark (2020) believe that allocating the factorisation of influences, which should be updated in probabilistic modelling, should be implemented based on the classical risk management methodology. This methodology considers not only probabilistic characteristics but also the level of their impact.

According to the results of scientific research by modern scholars (Benbya et al., 2020), the practical adaptation of traditional management process algorithms based on modelling processes is a primary component of the process of forming accurate and effective management decisions in order to implement effective economic activity under challenging conditions of uncertainty. At the same time, Benbya et al. (2020) argue that applying the functionality of modelling processes in the modern innovation field, with the involvement of digital optimisation tools, is a promising means of intensifying the effectiveness of management decisions during the crisis.

In their studies, some authors (Gečienė, 2020) emphasise the need to introduce the preliminary development stage of a plan of promising measures into the management paradigm in conditions of instability. They emphasise the need to take into account the principle of economic feasibility. Moreover, the authors emphasise that modelling is an effective analytical tool for efficiently processing massive volumes of data. The scientists' conclusions are synergistic with our study's results, which proves that modern probabilistic modelling capabilities ensure coordinated data management and effective adaptation of management decisions to unstable conditions.

As a follow-up to the research described above results, some modern scientists (Zhao et al., 2020) formulate the main requirements for the expected effectiveness of decision modelling in the management system, which include:

- minimisation of risks and levelling the consequential impact of the uncertainty factor on economic activity;
- creation of optimal conditions for investment;
- coordination of information flows that determine the vector of strategic decision-making within the management paradigm in crisis conditions of instability of socio-economic processes.

The modern process of forming a management strategy for the market entities' activities in the face of instability should be focused on optimising the availability, completeness, and speed of information and forming an appropriate concept of management decisions with accuracy and efficiency as priorities. Scholars whose studies have been outlined above are convinced of this. They assure of the need to introduce new interactive tools and expand the capabilities of the modelling process in the

field of research. Such processes should occur against active state and administrative innovation activities.

The mentioned research findings of modern scientists are identical to the conclusions of the current study, especially in actualising the need to use probabilistic models to increase their impact on forming and improving management decisions in the context of instability of the socio-economic field. The conceptual principles are the primary vectors for optimising the crisis management environment. At the same time, the main principle of crisis management in the context of unstable globalisation is to ensure the processes of analytics and market monitoring as the basis for forming alternative management decisions characterised by efficiency and accuracy. The outlined concept allows us to respond quickly to changes and adapt key management strategies. The government's regulatory policy plays an important role.

However, as of today, the number of studies on applying probabilistic modeling of managerial decisions in uncertain conditions still needs to be improved, marked by limited practical developments. Most studies are devoted to theoretical aspects and descriptions of modelling algorithms. The prospects for further research are seen in the formation of tools for making managerial decisions under an unstable economic environment based on the digitalisation of the probabilistic modelling process and the inclusion of artificial intelligence technologies in its functionality. This will allow for an individualised approach to the process while minimising the risks of making wrong decisions.

6 Conclusion

Providing sustainable economic performance in the face of an unstable socio-economic environment requires synergising efforts to develop effective strategic management decisions and the ability to quickly adapt to market dynamics. An integrated approach and considering a range of influential external and internal conditions ensure the effectiveness and accuracy of decisions within the management system. This approach ensures the formation of a reliable basis for further development and maintaining a stable position in the market in the face of uncertainty and changes.

As part of this study, we analysed the potential for optimising marketing strategies to build competitiveness and effectively promote goods and services in the face of instability and crises. The research proved that using innovative digitalisation capabilities in marketing systems allows for intensified performance and significantly increases companies' competitiveness under challenging conditions.

As a result of identifying the priorities of anti-crisis marketing, we proposed a universal algorithm for improving the efficiency of their implementation. The article diagnosed the multifactorial capabilities of modern innovative marketing tools, such as:

- optimisation of the quality communication processes;
- increase of competitiveness;
- prompt adaptation of supply to the demand dynamics;
- enhancement of the company's investment attractiveness.

The proposed model of anti-crisis marketing strategy reflects an interrelated set of strategic and operational measures subject to shared goals and tasks.

The study described practical tools for automating marketing processes that help optimise sales and increase profitability. The article also proposed priority directions for further scientific research on this topic, including developing practical functionality for anti-crisis marketing activities.

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