FEATURES OF MODELING OF ECONOMIC SYSTEMS IN CONDITIONS OF UNCERTAINTY

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The current stage of development of economic systems is characterized by high uncertainty, which significantly complicates their management. In the process of managerial decisions making, the problem of predicting the behavior of the system and the external environment is arises. The results of the forecasts require constant adjustment, which allows us to adapt to changes in the environment and flexibly respond to their negative impact. Modeling economic systems makes it possible to carry out many forecasts for various scenarios, depending on the dynamic formation of various situations of significant complexity and leads to an improvement in their management. Economic systems of different levels are in difficult situations and have an indefinite character of development, which makes it impossible to use traditional methods of mathematical modeling to select strategies for their safe development. Therefore, it is necessary to determine modeling methods that allow for timely and informed decision-making aimed at reducing the level of uncertainty in the functioning of economic systems.

In the scientific literature there is a significant number of interpretations of the concept of "economic system", since the approaches of various researchers depend mainly on the level of abstraction they have adopted. In our opinion, the definition of "system" is sufficiently fully disclosed by a team of authors led by V. Bazylevych (2006), "an economic system is a set of interrelated and appropriately ordered elements of the economy that form a certain integrity, economic structure of society". Taking into account the purpose of the study, economic systems are considered by the authors as complex probabilistic dynamic systems in which the processes of production, distribution, exchange and consumption of material and intangible benefits take place. In practice, economic systems of various levels function and develop under conditions of uncertainty of all their main factors: future states of the economy, finance, market, prices for resources and energy carriers, investment volumes, demand for a new product, chances, as well as the future financial stability of organizational units included in the system. Uncertainty is "an integral attribute of reality, therefore, for an adequate description of reality, it is necessary that the conditions of uncertainty are included in the applied modeling and optimization methods" (Madera, 2017).

A. Kolomytseva (2013) identifies the following types of uncertainties corresponding to different levels of knowledge about the studied system:

- uncertainties of type I – uncertainties due to lack of knowledge about the features of constructing an effective system descriptor of the studied processes, which meets the requirements of the external environment;
- uncertainties of type II – uncertainties due to lack of necessary information for diagnosing the state of economy and the implementing of developed models and methods;
- uncertainties of type III – uncertainties associated with the untimely identification of the discrepancy between the main characteristics of the state of economy with their reference value, while the task of overcoming the consequences of these discrepancies or overcoming their negative impact becomes very urgent.

The greater the uncertainty in decision making, the greater the degree of risk. A. Stirling (2007) proposed a matrix characterizing the interdependence of uncertainty and risk (Fig. 1).

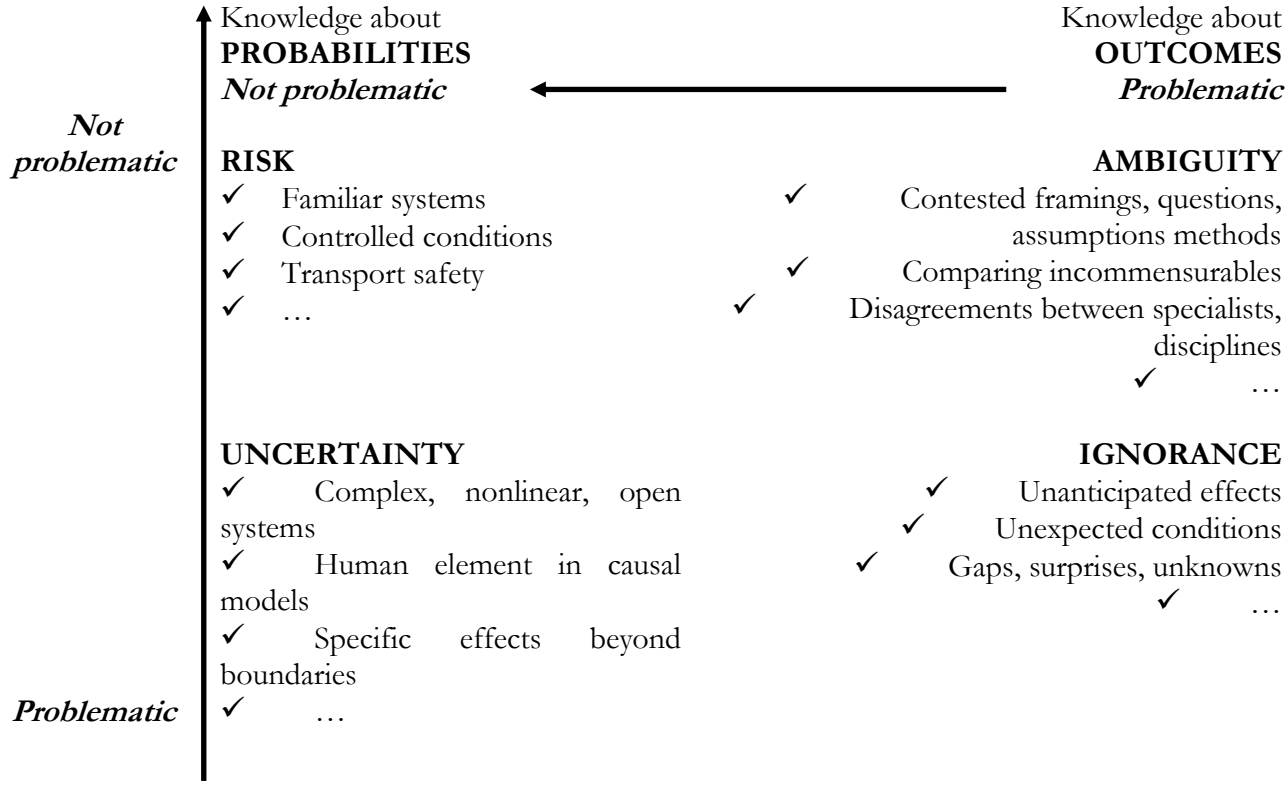

Figure 1. Risk and uncertainty matrix [12]

The matrix proposed by the researcher allows us to identify four types of situations in which economic and socio-economic systems function: risk, uncertainty, ambiguity and ignorance. The first option "risk" is relatively unproblematic for forecasting and modeling, can be quantified, which allows the use of statistical tools and methods.

Under uncertainty, we can characterize possible outcomes, but available information or analytical models do not provide sufficient basis for determining probabilities. In these conditions, they mainly use methods based on subjective judgments, expert assessments, etc., which do not give sufficiently substantiated results.

The third option "ambiguity" involves differences in assumptions, comparison of incompatible things, the main issues of trust and behavior, ethics and justice, and so on. Under these conditions, during the construction of models, the main problem arises not in the definition of probabilities, but with determining the directly possible scenarios for the development of events.

In a situation of ignorance, neither probability nor results can be determined. Ignorance differs from uncertainty in that the parameters are not only controversial but also at least partially unknown. This situation cannot be characterized as a risk, as the problem is not different opinions of experts or errors regarding probability, but ignorance of very possibilities.

Modeling of economic systems is the construction of a simplified image of an economic system for studying of its properties, forecasting, planning and calculations the consequences of management making decisions (Samsonova, 2018). The modeling is based on the principle of analogy and allows you to study the object under specific conditions, taking into account a one-sided point of view. An object that is difficult to study is studied not directly, but through consideration of its model (Vlasov&Shimko, 2005). The model of the economic system is a reproduction of the economic environment elements, the processes of their interaction and functioning, the reactions to changes in the environment.

Modeling of economic systems in increased uncertainty conditions of development should be carried out using scenario and simulation approaches, which are the most adequate for solving this problem.

Scenario modeling is "a tool for constructing not separate development trajectories, but a wide range of options for assessing the impact of various factors; is very effective in choosing the targets of

the strategy of economic system development and in assessing possible risks" (Hrytsenko&Bazhan, 2014). In the scenario approach, several scenarios of economic system development are considered, from which only one is selected, which transfers the system to a safe state. V.V. Kuznetsov (2004), D.A. Kononov, V.V. Kul'ba et al (1999) note that the application of a scenario approach is a fairly flexible tool for strategic planning.

The goal of modeling in the scenario approach is to build and implement a mathematical model of the economic system development and conduct experiments on its basis in order to reduce uncertainty by reflecting possible ways of development. In this case, the following steps are performed:

1. Determining the studied system structure, its input and output variables, control variables, controlled and uncontrolled parameters.
2. Formation the economic system states and determination of the main goals of its safe development of the corresponding scenario.
3. Formalization of the scenario model of the economic system safe development according to the selected criteria.
4. Choice of tool for implementing the scenario model.
5. Construction of scenario development options using the constructed model.
6. Analysis of alternative scenarios for the development of the system (Hrytsenko&Bazhan, 2014).

The use of a scenario approach involves the construction of models that explain the nature of phenomena and processes in the economic system; allow to carry out an assessment of a situation and the analysis of significant factors influence; determine the mechanism of interaction between the participants in the system and identify trends in its development; to produce directions of situation management; evaluate the results and consequences of management decisions; justify the choice of optimal strategies for the development of the economic system. It should be noted that typical scenarios need to be accumulated in order to develop all the most likely scenarios for the development of the situation in conditions of uncertainty (Bielaj, 2015). This will allow identifying all the typical situations for which it is necessary to develop state regulatory mechanisms.

Simulation is considered as an "experimental method for studying a real system according to its model, which combines the features of the experimental approach and the specific conditions of using computer technology" (Il'in, 2007). According to scientists [8, 10, 13, 15], this type of modeling is one of the most effective methods of studying economic systems. It is usually used in the following cases:

- in the management of complex business processes, when the simulation model of the economic system is used as a tool in the adaptive management cycle based on information technology;
- in experiments with discrete-continuous models of complex economic systems to track their dynamics in risky situations;
- in assist the decision-making process in order to study their alternatives and reproduce various scenarios for dissimilar input conditions.

S. Zhuravlev (2009) suggests the following steps in building a simulation model:

1. Formulation of the research goal.
2. Collection of information and data.
3. Development of a conceptual model.
4. Checking the conceptual model for the adequacy of the task and performing structural critical analysis.
5. Translating the conceptual model to simulation software acceptable form.
6. Verification of the obtained model.
7. Return to items 1 – 3 (depending on the detected error) in case of inadequacy of the obtained model.
8. Development, implementation and analysis of experiments.
9. Documentation and presentation of the obtained results.

A feature of economic systems simulation is the ability to reproduce them while maintaining the logical structure and behavioral properties. Among its advantages are: reflection of dynamic processes and behavioral aspects of the environment; the possibility of complex systems functioning, identification of trends and patterns of their development in terms of incomplete and inaccurate

information; implementation of the principles of object-oriented design and application of high-tech solutions in the construction of computer models, etc. (Lychkina, 2013).

Note that simulation has some disadvantages from the point of view of application in a particular situation. In addition, the development of information technology leads to the need for continuous improvement of its systems and the decisions that are made in them.

S. Parinov (2007) notes that the main purpose of simulation is to improve the functioning of economic systems both by correcting malfunctioning organizational mechanisms and by finding new approaches to the organization and management of processes. Simulation allows not only predicting the economic system behavior, but also to learn about the interaction of its components; solve problems of high complexity; simulate various processes with many levels and elements, taking into account the complexity of the relationships between them.

Thus, the economic system operates and develops in conditions of uncertainty, due to the exciting effects of the external environment. Modeling is an important tool to support decision-making in economic systems, since it allows you to explore a large number of alternatives and reproduce different development scenarios for each option. Scenario modeling makes it possible to develop a list of the most likely scenarios for the development of economic systems in conditions of uncertainty and is an important element of the strategic decision support system. Simulation allows you to study and predict elements of economic systems and their interaction in uncertain conditions with incomplete and inaccurate data.

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