Economic Cybernetics: Development Paradigm and Global Modeling in the Modern World

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Abstract: Economic cybernetics is a relatively young science, but at present, its methods are widely used for the accumulation and analysis of data, and many other operations. Due to the fact that economic cybernetics is in the stage of active development, the relevance of this article is due to the need to identify further prospects for its evolution. To do this, it is necessary to consider the philosophical basis of economic cybernetics, as well as the applied cybernetic methods of various areas in the field of economics. The primary forms of this work are analysis and comparison. The study reveals three stages in forming economic cybernetics as manifestations of scientific rationality, their main ideas, genesis, and paradigms. In order to take a deeper look at the variability of the application of economic cybernetics, examples of third-generation models with the corresponding mathematical apparatus in the field of studying the analysis of the level of corruption, managing the logistics information system, and assessing the impact on employee productivity when changing working conditions are given. The paper considers regression models, a system of simultaneous equations, a queuing system theory method, and an ordinal multiple regression model to determine the influence of various variables on one ordinal variable. A comparison of the above methods and their main advantages and disadvantages are identified. The work may be of practical value in the development of new models of economic cybernetics.

Keywords: Information Management; Automatic Control System; Calculations; Data Analysis; Scientific Rationality.
JEL Codes: C15, P48, F02.

1. INTRODUCTION

Economic cybernetics is a field of science that deals with using modern mathematical tools to analyze economic systems. It explores the economy and its structural and functional components as systems in which the processes of regulation and management are carried out through the movement and transformation of information. With the help of its methods, it became possible to standardize and streamline the reception, transmission, and processing of information in the field of economics (Petersone and Ketners, 2017). They also allow you to develop the structure of models for data processing. At the same time, economic cybernetics is still in its infancy. It is also important to note that the term "economic cybernetics" is typical only for the countries of the post-Soviet space. In global practice, the concept of "applications of cybernetics in economics" is used (Aizstrauts et al., 2013; Ginters, 2020).

It can be an obstacle to a free market economy, but in times of crisis, the cybernetic process must be applied to any economic system to establish order. The global coronavirus pandemic has caused national economic structures to nearly collapse due to a lack of advanced contingency planning (Mishchenko et al., 2021). Thus, one can conclude that a free economy is not adapted to crises. At the same time, the planned economy does not provide opportunities for free enterprise and tax cuts, suppressing the country's economy to a certain extent. A possible solution is a combined system, i.e., a command-and-control structure that ensures smooth operation but provides for independence in the market to guarantee freedom of activity within the control framework (Lange, 2014; Rowbotham, 2021; Kisiołek et al., 2021). In this case, it is necessary to introduce the methods of economic cybernetics into the structure of the economies of the countries of the world.

To increase the competitiveness of enterprises in various industries, it is necessary to modernize them. In the article by G.V. Fedotova et al. (2019), from the standpoint of the cybernetic approach, interaction at the level of electronic means of administration and management is considered, that is, taking into account the active development of the economic system and the use of electronic interaction tools. The researchers determined that to maintain such a system's performance, it is necessary to improve knowledge about the economic process constantly. This work applied normative analysis and evaluation methods to manage the development of innovations and science. In addition, there are publications aimed at analyzing and researching investment decisions. Authors N. Chiriță et al. (2021), with the help of R

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Studio and Altreva Adaptive Modeler programs, analyzed and modeled the stock market for 5 well-known companies: Microsoft, Oracle, Accenture, Cisco, Intel, and IBM. The proposed concepts can be used to create an environment that encourages people to make good investment decisions, given the dynamic environment in which they operate (Petryshyn and Hyliaka, 2021; Kuchma and Gatalevych, 2022).

The COVID-19 pandemic has changed priorities in the global market. The global crisis gave a new impetus to the development of economic cybernetics, as a result of which many publications on this topic have appeared (Yaroshenko and Tomashevski, 2021). In their study on changing shopping habits, Romanian researchers I. Cetină et al. (2022) presented a model that studied the factors influencing consumers' intentions to purchase on the Internet. The theoretical relationships of the model were tested using factor analysis, structural equation modeling, and mediation analysis. The results of this work contribute to the understanding of consumer behavior on the Internet, offering a new framework for developing practical marketing strategies. A similar question was raised in an article that analyzes the fluctuations in online retail prices during the lockdown phases, comparing figures to previous years. The results of the authors B. Posedaru et al. (2022) indicate a low degree of correlation between the growth in demand for certain products and restrictions associated with COVID-19. N. Chiriță and I Nica in their article (2020) also applied the methods of economic cybernetics in this situation. A model was created for the capital market behavior in several countries in the context of the coronavirus. The results showed the extent of the deterioration in the situation in the stock market. The proposed measures are aimed at supporting the economy and jobs, as well as providing fast and efficient remote banking assistance (Mishchenko and Mishchenko, 2016; Ketners and Petersone, 2021).

The disadvantage of these articles is the narrow focus in this area. It is necessary to expand the possibilities of this science for the further implementation of cybernetics methods in the economic sphere of any country in the world. This work aims to describe the formation of economic cybernetics as a field of science to determine functional and structural changes and the prospects for transformations in the global world.

2. MATERIALS AND METHODS

The methodology of this study is based on the following methods: systemic, which made it possible to reveal economic cybernetics in three generations of its development, as well as analysis and comparison of modern models of this branch of science. With the help of these methods, the period of formation of this direction was studied, and the distinctive features of each generation were considered. Mathematical models that are currently used in the economy were presented. The study was carried out in four main stages.

In the first stage, with the help of the analysis method, the origin of economic cybernetics as science is considered. Scientists and researchers who influenced this direction's formation and further development were presented. It is indicated how these methods were introduced in socialist countries in the middle of the twentieth century. The factors and events that contributed to the active evolution of the new science are considered. The main directions in this area are revealed.

The second stage presents the philosophy of economic cybernetics. Using the systematic research method, the proposed science is considered an integral system of scientific rationality. The structures of the object and its elements, their functioning, as well as the genesis of the system have been comprehensively studied. The philosophical directions that influenced the formation of economic cybernetics at all three stages of development are determined. The paradigms of each generation are considered. Thus, a description of each generation is given as manifestations of three directions of scientific rationality: classical, non-classical, and post-non-classical. The reasons why the third generation of economic cybernetics is currently in the formation process are indicated. The value of young science for society is explained.

In the third stage, the method of analysis was also used, which contributed to the study of the methods of economic cybernetics of the third generation and the ways of their implementation in the economy. The present study uses regression models and a system of simultaneous equations. Formulas are given to measure the positive effects of the reform process, determine the conditions for performing this function, the cost of the reform process, and the net income received as a result of the development of the reform process. At this stage, those countries of the world that have the most significant number of works on this topic are also noticed to determine the leading institutions of economic cybernetics.

In the fourth stage, modern models of this direction are presented. In this part of the study, intelligent control modeling procedures in a logistics information system are considered and solved by the queuing system theory method. For a brief description of this method, the formulas for determining the effectiveness of the system and the quantitatively measurable goal are given. Mathematical techniques were used to assess the impact on employee productivity when switching to remote work. A description is given of the formulas for changing employees' productivity while working from home and determining employees' preferences regarding the workplace after remote work experience. A comparison of modern and earlier cybernetic methods in the field of economics is carried out, and the main advantages of new methods, techniques, and the applied mathematical apparatus are highlighted.

3. RESULTS

Economic cybernetics investigates the mechanism of action of information data in the country's economy and evaluates their influence on the organization of these processes. The British scientist S. Beer was the first person to apply a cybernetic tool to management problems in the field of economics. His works had a significant influence on the evolution of economic cybernetics, he made a considerable contribution both to the methodology and to the theory of this science (Ramage and Shipp, 2020). The theory and practice of national economic planning and management in the USSR (Union of Soviet Socialist Republics) and other socialist countries were of fundamental importance for economic cybernetics as a socialist tool. In the 1950s and 1960s, the issues of building data processing systems were actively stud-

ied. This included researching and optimizing data flows, coding, and data processing organization.

As a result of the research, computers began to work more efficiently since, previously, they were used mainly for one-time calculations. As an explanation of the theory of automatic control, diagrams were constructed to regulate economic systems, some of which were very abstract. All these studies gradually merged and formed the field of economic cybernetics. Small data processing systems in enterprises have steadily developed into information systems for analysis and planning at the industry and national levels, forming the general features of this area (Nazemi et al., 2015). The question arose about the information support of large-scale systems of economic models. Combining models of managed objects and management processes has become the basis for planning automated control systems (ACS). With the solution to this problem, it was possible to develop and implement effective plans that meet the specified requirements of the regulatory authority to create an optimal control system (Rowbotham, 2021; Kyzyrkanov et al., 2021).

In 1967, economic cybernetics was one of the most progressive branches of science, at that time, there was a rapid growth of scientific achievements in this area. The cybernetics of the economy was mainly influenced by linear programming methods by L. Kantorovich. A. Berg (1968), a Soviet scientist, was actively involved in developing economic cybernetics. At his suggestion, the section "Economic Cybernetics" was created, which coordinated the main directions of the new science: the theory of economic systems, the idea of financial information, the theory of economic control systems, methods for designing ACS in the national economy, the methodology for studying financial information flows and designing data processing systems, analysis, and development of mechanisms for optimal financial management. In 1966, the First All-Union Conference on Economic Cybernetics was organized. The problems of this branch of science were formulated, and the available scientific and practical results were summarized and systematized (Markova et al., 2017).

There are three generations of the development of this science, which correspond to some regions of philosophy. Cybernetics of the first generation is based on the principles of classical scientific rationality, namely: focusing attention on the object and the desire to eliminate everything that belongs to the subject. The initial stage in the formation of economic cybernetics is considered to be the 40-70s of the twentieth century, at which time the philosophy of positivism had a significant influence. The classical representation of cybernetics at the beginning of its existence was limited to the "subject-object" paradigm. Under these conditions, to create models of processes in the field of economics, the following approaches were used: functional, informational, axiomatic, operations research, etc.

The second generation of economic cybernetics is based on non-classical scientific rationality. In this view, the links between knowledge about the object and operations of activity are considered. Studies of this period are associated with the transition from positivism to philosophical constructivism. The idea of an active object, or an explorer object, which was proposed by H. Förster, is fundamental to this generation. Thus, it can be summarized that the first generation of economic cybernetics is the cybernetics of observed systems, and the second-generation cybernetics, in turn, removed the restriction between the object and the subject of control, becoming the cybernetics of monitoring systems. The main concepts of the second generation are objectification and reflection (Lecomte, 2022). The works of this period created the basis for the transition from the "subject-object" paradigm to the new "subject-subject" paradigm. Thanks to this transformation, new ways of managing economic systems have emerged. For example, these are control of active systems, information control, reflexive control, etc.

Economic cybernetics of the third order refers to post-non-classical scientific rationality. In this type, the correlation of the acquired knowledge about the object with value-target structures is taken into account, an explanation is given of the relationship between intra-scientific goals with extra-scientific, social values, the problem of correlation, and understanding of the value-target orientation of the subject is solved. This generation of economic cybernetics plans to introduce a "polysubjective environment" into scientific research and the problems of managing the structures of the economy. This environment is a self-developing system. At the same time, a new paradigm, "a subject – a self-developing polysubjective environment" arises, which is inseparably linked with the formation of a subject-oriented approach. The methodological foundations of this approach were developed to improve the state's automated organizational management system. However, there is another paradigm, which is based on the principle of "subject-meta subject". This is because cybernetics of the third generation has not been finally formed (Lepskiy, 2015).

The primary attention in this article is given to scientific publications corresponding to the third generation of economic cybernetics. Its methods are used in various sectors of the economy. An example is an analysis of the level of corruption and an assessment of its impact on economic and social processes in the country. In order to join the European Union (EU) in the mid-2000s, the Romanian government needed to carry out intensive public administration reforms. In line with the requirements for EU accession, the critical reform was decentralization and improvement in the process of public policy-making. The public administration reform is determined by the strategy adopted by the Romanian government in 2004. From this perspective, the following components of the reform process have been identified. The first component is the civil service reform by improving its management, the process of forming civil servants. The second is the reform of the local public administration, as a result of which the process of decentralization is being carried out. The third is the improvement of the public policy process. According to this strategy, the process of decentralization will help to reduce the level of corruption (Shostko, 2020). Romanian researchers T. Andrei et al. (2009) analyzed the level of corruption using regression models and a system of simultaneous equations. The calculations used a series of data registered based on an analytical sample of civil servants.

The used models with a system of simultaneous equations for corruption analysis have some advantages in terms of

parameter estimation. This study considers the exogenous nature of the variables, and the estimated parameters are not biased and consistent. The article's author set three goals, based on which the methodology was formed, and designated them as follows. O1 – improve the regulation of state functions, stabilize and strengthen the activities of state bodies. O2 – create new mechanisms by which the central government will better cooperate with local public administrations. O_3 – improve the national and local policy-making process to strengthen the government's administrative capacity. To determine the positive impact of the reform process R_i, the author provide the following functions (1):

$$R_i = R_i\left(A_{i1}, \dots A_{ip_i}\right) i = 1, 2, 3, \quad (1)$$

where: A_{ij}, at $j = 1, \dots, p_i$ – a set of planned actions aimed at supporting the set goals O_i; p_i – the number of planned actions to achieve the set goals.

In the medium and long term, reform actions will benefit public administration by improving the quality of services, reducing the costs of running public institutions, reducing corruption, etc. Each function assessing the positive impact in these areas will be directly influenced by aspects of the reforms, as measured by the amount of activity allocated to each action within the strategy. For this, it is necessary that the condition (2):

$$\frac{\partial R_i}{\partial A_{ij}} > \ i = 1, 2, 3 \ at \ j = 1, 2, \dots, p_i. \ (2)$$

Applies the model used to determine the cost of the C_i reform process through the functions (3):

$$C_i = C_i\left(A_{i1}, \dots A_{ip_i}, \boldsymbol{B}, \boldsymbol{P}\right) i = 1, 2, 3, \quad (3)$$

where: $\boldsymbol{B} = (B_1, \dots B_q)$ – a vector variable that means the system's positive response to the reform process; $\boldsymbol{P} = (P_1, \dots P_m)$ – a vector variable that describes the ability of the political system to support the public administration reform process.

The vector variable **B** describes the influence of the following factors: the mobility of public administration employees, the ability of public administration to organize competitions for replacement or promotion correctly, the level of equipment of public administration institutions with information systems, etc. The vector variable **P** implies the actions of the political system on government bodies. These include: political uncertainty in the promotion of some reforms, pressure on government bodies from the political system, corruption in government bodies, etc. The net income received from the development of the CN reform process is determined by the function (4):

$$CN = \sum_I \left(R_i\left(A_{i1}, \dots A_{ip_i}\right) - C_i\left(A_{i1}, \dots A_{ip_i}, \boldsymbol{B}, \boldsymbol{P}\right)\right). \quad (4)$$

Considering the current situation with Ukraine's accession to the EU, this methodology can be used in carrying out the relevant reforms. The existing experience of other countries should be used to improve the process of European integration. It should be noted that according to the results of the analysis of global trends and features of publications in the field of economic computing and economic cybernetics research from 1969 to 2020, Romania ranks first in terms of the number of publications in the authoritative international journal in the field of economics "Economic Computation and Economic Cybernetics Studies and Research". The authors of this work are W.U. Xianli et al. (2020). The publication includes bibliometric methods for the analysis of articles from the side of the academic structure and the assessment of relevance. A detailed study of the content of publications and citations, keywords of essays, research topics, as well as international co-authorship was analyzed. Romanian scientists account for the most significant number of publications on the subject of economic cybernetics.

Therefore, Romania in this period is a leader in the development of this area. There is close cooperation between scientists from several countries, including Romania, Lithuania, and China. Cooperation between researchers is essential because the interaction between international institutions contributes to the further evolution of economic cybernetics (Lu et al., 2022). The author noted that South Korea rarely cooperates with other states in this area of research. Although Korean scientists have a large number of publications in this field, the level of scientific novelty in these works is much lower compared to those countries that actively cooperate. It is necessary to use the knowledge and experience of more developed countries to obtain.

Economic cybernetics has also found its application in the organization of transportation. In recent years, functional and structural changes in the mathematical apparatus of the methods of economic cybernetics have been observed (Cherunova et al., 2019). S.A. Alomari et al. (2020) intelligent procedures for modeling the management of a logistics information service system in the class of tasks solved by the queuing system theory method are considered. Logistics plays a vital role in the economy, so effective management in this area is necessary to improve the level of customer service (Ginters et al., 2013). This study presents new ways to build mathematical models for managing logistics information systems. The processes of building a logistics system must correspond to the joint coordination of materials or products, employees, and information. The goal of any management system is to meet the needs of society, and the degree to which the system meets the goals set is called its effectiveness (Perkins and Jessup, 2021). In the presented work, the efficiency of the system *E* depends on its own characteristics *Z*, environmental parameters (input actions) *X* and goals A_s (5):

$$E = q(Z, X, A_s), \quad (5)$$

where: q is the efficiency criterion.

Depending on whether it is possible to find the available q, which specifies the numerical value of efficiency, one distinguishes between qualitative and quantitative goals. A qualitative goal does not imply the specification of a particular substantive condition. Therefore, the purposes of ensuring the system's operation and the execution of the plan are qualitative. The corresponding criteria can take only two values: 1 – if the condition is met and 0 – if the situation is not met. The quantitatively measurable goal A_s is set by the desire to increase the efficiency value (6):

$$A_s = \max_{x \in X} q(Z, X) \qquad (6)$$

Quantitative goals allow you to improve the process of functioning of the system and its management. Qualitative goals, as a rule, do not have a degree of certainty sufficient to build a mathematical model. The type of efficiency criterion q depends on the characteristics of a particular system. The experience of constructing performance criteria allows us to generalize some principles that help prevent errors. The principles described in this article will enable you to optimize the studied economic system as much as possible. Recent studies in the field of economic cybernetics are mainly related to the global coronavirus pandemic. N. Isac et al. (2022) studied the impact on employee productivity when switching to remote work. Virtual snowball sampling was used to collect data, explanatory factor analysis was used to reduce the number of variables, and ordinal logistic regression analysis was used to analyze the impact of respondent characteristics, socio-demographic and socio-economic variables on employee performance. An ordinal multiple regression model is used to determine the effect of different variables on a single ordinal variable. In this study, the dependent variable is the change in employee productivity during quarantine (7). Whereas, to determine the effect of different variables on a single dependent variable with more than two non-ordinal responses, the author uses a polynomial regression model (8). The following equations have been used to evaluate the regression models:

$$Y\alpha = \beta 0 + \beta 1X1 + \beta 2X2 + \cdots + \varepsilon i, \qquad (7)$$

$$Yb = \beta 0 + \beta 1X1 + \beta 2X2 + \cdots + \varepsilon i, \qquad (8)$$

where: $Y\alpha$ is the change in employee productivity during the lockdown; Yb – employees' preferences regarding the workplace after the experience of remote work; $X1$, $X2$… – a group of socio-economic, socio-demographic variables and variable working conditions; $\beta 1$, $\beta 2$ – regression coefficients; εi – error condition.

The results of this study may allow organizations that have adopted remote work to understand the factors affecting employee productivity and improve working conditions. Cybernetic methods of recent years, applied in the field of economics, have a more powerful and multivariate mathematical base. Due to the fact that software for solving applied mathematical problems is actively developing, it has become possible to solve complex and voluminous economic issues. Compared to the methodology in the 2009 paper (Andrei et al.,), where the authors analyzed the level of corruption using regression models and a system of simultaneous equations, the polynomial regression used in the 2022 paper (Isac et al.,) is more flexible and allows modeling more complex relationships.

4. DISCUSSION

In one of the publications of recent years, the philosophy of socio-economic interconnection is considered from the standpoint of the cybernetic approach. In the work of M. Kozlov (2021), it is proposed to consider socio-economic cybernetics as the development of social cybernetics and cybernetics of the third generation. In the analysis of this issue, works on the general theory of systems by L. Bertalanffy and the concept of the philosopher V. Stepin on post-non-classical rationality were applied. The author studies forming third-generation cybernetics based on self-developing active media. The publication also contains various works in the field of decision theory, political science, sociology, and behavioral economics.

In his work, the scientist V. Lepskiy (2018), a professor and specialist in the field of automatic processes in management, developed a connection between the development of cybernetics and scientific rationality, emphasizing the relevance of the formation of post-nonclassical cybernetics for a self-developing reflexively active environment, or third-generation cybernetics. The presented work contains an analysis of the evolution of this direction. The connections between classical, non-classical, and post-non-classical scientific rationality and the stages of development of cybernetics are determined (Medvedeva and Umpleby, 2022). As already mentioned, classical rationality is first-generation cybernetics dealing with observable systems or an external observer. Non-classical rationality is second-generation cybernetics related to the internal observer. Post-nonclassical rationality is third-generation cybernetics, which refers to a self-developing reflexively active environment, which can also be designated as a distributed observer. This analysis opens up new approaches to social control based on subject-oriented models and integrating traditional cybernetic tools. Third-order cybernetics contributes to the development of a democratic society (Sarybayev et al., 2021). Hence, the value of the study lies in an interdisciplinary analysis of the evolution of cybernetics and new possible directions for its development.

Authors K. Lawler et al. (2020) represent a new vision of this science. Researchers believe economic cybernetics should use a systems paradigm that is interdisciplinary, holistic, higher quality, and abductive rather than inductive. The new perception should include the following factors: economic growth, access to the global economy, and the introduction of algorithmic management in the labor market. It is also proposed to create cybernetic regulation models using optimal control. New economic thinking should promote the creation of a circular economy, not a linear one. The fundamental idea of economic growth must be reoriented. The researchers also emphasized that the focus should be on the global natural product, with an emphasis on the sharing of existing benefits and not on the gross national product. The economy must be seen as a way to achieve this goal, even if it may never be reached, at least not in a short per. This is consistent with the holistic nature of systems thinking, which allows you to capture the whole picture.

As for the mathematical apparatus, the methods of economic cybernetics are used to solve complex problems of the transitional economy. An article by Ukrainian academician I.V. Sergienko (2012) reveals the pro of information technology development in the Ukrainian economy. At the same time, attention is paid to the study of the interaction between the real and finblemsancial sectors of the country, as well as to consideration of the features of the transitional economy, including the abundance of various forms of imperfect competition (monopoly, oligopoly, monopsony, etc.), the simultaneous operation of several pricing mechanisms, various

large-scale manifestations of the shadow economy (Ginters et al., 2014).

The issue of the shadow economy in the example of Ukraine was also raised in the article by Y. Bilan et al. (2020). The study's primary purpose is to study the relationship between the gross domestic product (GDP) indicators and the shadow economy. The paper analyzes the methods of influence of the shadow economy and identifies its main consequences at the social, political, and economic levels. After analyzing the indicators of average GDP growth rates in the European Union member countries for the period from 1960 to 2016, it was determined that, as of 2020, the level of economic growth in Ukraine, compared to other countries, is much lower. Using the results of the analysis of static indicators of socio-economic stability, such as standard deviation, coefficient of variation, and maximum and minimum values, direct and inverse relationships were demonstrated between the degrees of shadow economy and GDP (Naumenkova et al., 2022; Dmytruk et al., 2022). Economic cybernetics is also used in the container transportation market for accurate forecasting and analysis of developments in the logistics field.

In an article by Chinese scientists R. Wang et al. (2009), a forecasting model of this science is created for the container transportation market, the market structure, regulation, and factors of influence of the container transportation market are analyzed from three main aspects: the needs subsystem, the supply subsystem, and the freight subsystem. Based on them, the model is used to predict and model the container transportation market, determine the system's stability, control with feedback and optimize decisions. The expected result and the actual data are consistent with each other, so the model accurately reflects the container transportation market. The application of such models can effectively assist decision-makers in liner shipping companies in making production and management decisions such as container ship capacity allocation and ship route planning (Kostruba and Hyliaka, 2020).

Malaysian researchers A.M. Baba et al. (2021) considered identifying spatial outliers in the article. This method is necessary to reveal confidential information in various areas of the application of statistics for large amounts of data. The Score Statistic method was used as a diagnostic tool to identify spatial outliers. The study has identified the most effective ways to detect spatial outliers in data sets. In the context of the study by B. Mârza et al. (2021), a framework for the financial responsibility process is proposed that can raise awareness of the most basic harmonized key levels of economic and digital inclusion, which, if properly managed, can lead to the achievement of an optimal level of financial responsibility, and on the other hand, assess the process of economic and digital integration of two different age groups of people, actively working in the economic environment. The Analytical Hierarchy Process (AHP) and Fuzzy AHP approaches are proposed as a basis for assessing the mechanism of financial and digital inclusion in five countries of Eastern and Central Europe (Kisiołek et al., 2022).

Financial institutions are faced with the need to assess the creditworthiness of a borrower who applies for a loan. For this reason, data scientists can gain essential insights that explain customer behavior. A. Coşer et al. (2019), an analysis of a database of clients proposed, some of which could not repay the loan and ended up in a state of default. Using a data mining methodology and machine learning algorithms, a series of predictive models were developed using classifiers such as LightGBM, XGBoost, Logistic Regression, and Random Forest to estimate the likelihood of a customer defaulting on a loan. Three sampling scenarios were created to compare the classification between unbalanced and balanced datasets. In addition, an analysis of the comparison of models was carried out to identify the best classifier, taking into account the performance indicators of the model: AUC (Area Under the Curve), Precision, Recall, and Accuracy.

This article does not cover all aspects of the philosophical principles of economic cybernetics, as was done, for example, in the works of M. Kozlov (2021) and V. Lepskiy (2018). The result gives only a brief overview of the prospects for the transformation of economic cybernetics of the third generation. It compares the change in the efficiency of the mathematical apparatus used in this area. The article considers general concepts and ways of applying cybernetic methods in the economic sphere. The listed publications present ways to use cybernetics to obtain specific results, such as a container transportation market forecasting model (Wang et al., 2009) spatial outlier identification (Baba et al., 2021), borrower creditworthiness assessment (Coşer et al., 2019), etc. There is a large amount of software and related mathematical apparatus, some of which have been described in this study. The general outline of the structure of economic cybernetics will allow us to take a broader look at the opportunities that this industry opens up. Although this direction successfully solves the tasks set, there are still many ways for its further evolution. It is necessary to continue developing its philosophical basis, which will contribute to creating new effective models.

5. CONCLUSIONS

Economic cybernetics is a promising direction in the modern world. Its mathematical methods make it possible to analyze the structural and functional components of the economy and streamline the reception, transmission, and processing of data. It found its application as a theory and practice of national economic planning and management during the existence of the USSR. Given the global economic downturn resulting from the COVID-19 pandemic, many countries worldwide may turn again to its methods, as they help ensure the system's smooth functioning during the crisis. A command-and-control structure based on cybernetic strategies may somewhat narrow the freedom of activity in the market. Still, it can guarantee the economy's stability during any difficult periods of the state. The article considers the origins of this area of cybernetics, the period of formation, and factors contributing to the development of this science. The philosophical basis of this industry is scientific rationality. There are three generations of economic cybernetics. The first generation is based on the principles of classical scientific rationality, its paradigm is "subject-object". The second generation refers to non-classical scientific rationality, the new paradigm of which is "subject-subject". The third generation is post-non-classical scientific rationality, it continues to form at present. For this reason, the central paradigm of this generation is not clearly defined.

The following studies were presented as examples of economic cybernetics. The analysis of the level of corruption based on the regression model and the system of simultaneous equations is considered. Intelligent management modeling procedures in the logistics information system were also described, solved by the queuing system theory method and an ordinal multiple regression model to determine the influence of various variables on one ordinal variable, which was used to assess the impact on employee productivity when switching to remote work during the COVID-19 pandemic. As a result, modern methods of economic cybernetics of the third generation contain more advantages than ten-year-old models since they have a more advanced mathematical apparatus. However, it is necessary to continue the development of this industry to processes further optimize computing and data processing. The study also identified countries that are leaders in developing economic cybernetics. It is necessary to use the experience of international institutions and actively cooperate with them to create economic cybernetics. customer service. This study presents new ways to build mathematical models for managing logistics information systems.

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