UDC 332.012

Igor Oliychenko, Maryna Ditkovska

BIFURCATION AND SYNERGETIC APPROACH TO THE MANAGEMENT OF SOCIO-ECONOMIC SYSTEMS

Ігор Олійченко, Марина Дітковська

БІФУРКАЦІЇ І СИНЕРГЕТИЧНИЙ ПІДХІД ДО УПРАВЛІННЯ СОЦІАЛЬНО-ЕКОНОМІЧНИМИ СИСТЕМАМИ

Игорь Олейченко, Марина Дитковская

БИФУРКАЦИИ И СИНЕРГЕТИЧЕСКИЙ ПОДХОД К УПРАВЛЕНИЮ СОЦИАЛЬНО-ЭКОНОМИЧЕСКИМИ СИСТЕМАМИ

The article focuses on the theoretical foundations of synergetic approach to the management of socio-economic systems and fluctuations as an incidental changes to the system. According to fluctuations the system chooses the path of further evolution. Theoretical concepts and methodological foundations of a synergistic approach have been studied. The differences between a system approach and synergetics have been identified. The main principles for the synergistic approach in the management of socio-economic systems have been suggested.

Keywords: *evolution, non-linear environment, fluctuations, attractors, open systems, deterministic chaos, information, information systems, decentralization, decision-making.*

Tabl.: 1. Bibl.: 10.

Розглянуто теоретичні основи синергетичного підходу до управління соціально-економічними системами і біфуркації як випадкові зміни в системі, відповідно до яких система вибирає шлях подальшої еволюції. Вивчено теоретичні концепції і методологічні основи синергетичного підходу. Ідентифіковано відмінності між системним підходом і синергетикою. Були запропоновані основні принципи синергетичного підходу в управлінні соціально-економічними системами.

Ключові слова: *еволюція, нелінійне середовище, флуктуації, атрактори, відкриті системи, детермінований хаос, інформація, інформаційні системи, децентралізація, прийняття рішень.*

Табл.: 1. Бібл.: 10.

Рассмотрены теоретические основы синергетического подхода к управлению социально-экономическими системами и бифуркации как случайные изменения в системе, в соответствии с которыми система выбирает путь дальнейшей эволюции. Изучены теоретические концепции и методологические основы синергетического подхода. Идентифицированы различия между системным подходом и синергетикой. Были предложены основные принципы синергетического подхода в управлении социально-экономическими системами.

Ключевые слова: *эволюция, нелинейная среда, флуктуации, аттракторы, открытые системы, детерминированный хаос, информация, информационные системы, децентрализация, принятие решений.*

Табл.: 1. Библ.: 10.

JEL Classification: P 00, P 40, P 41

Problem statement. Analysis of the current state of management of complex organizational systems shows that there is a complex problem of the effective management of social-economic systems with using of modern information technologies. On the one hand, there is the rapidly evolving methodology of information support of management, on the other hand, developed methods, techniques, systems and technology have little effect on management practices, and do not enable of socio-economic system to rise on a higher level of development. The question is where is the source of contradictions in the methodology or in management practices? To answer this question it is necessary to analyze the use of modern management approaches in particular synergetic approach to the information systems in management in social-economic systems.

Analysis of recent research and publications. The study of theoretical and methodological aspects of using synergetic approach in management of social-economic systems, considered in studies of Dobronravov I.S., Bilous V.S., Derbentsev V.D., Ilchenko B.V., Nicolis G., Haken G., Knyazev E.N., Kurdyumov S.P., Malinetskii G.G., Milovanov V.P., Bevzenko L.D., Bogutsky Y.P. However, despite the significant achievements of these authors remain poorly studied issues related to the use of synergetics as an approach for research of information support of management of social-economic systems.

Allocation of the unsolved earlier parts of the overall problem. Despite the research of development of management of social-economic systems, the problems of implementing effective information support to this management not enough researched. One of the important

problems is using of basic synergetics ideas to improve of information support of management at all levels of social-economic system. Therefore, the problem of using a synergistic approach to support of management in social-economic systems is particularly relevant.

The objectives of the article. The purpose of the article is research of information support of management in social-economic systems with using of synergetic approach. The object of the study is the process of formation and using of synergistic approach to information support of management. The subject of research is theoretical concepts and practical approaches to the introduction of synergetic approach to information support of management in social-economic systems.

The main results of the study. In synergetics we use the terms fluctuations, attractors and bifurcation point. Fluctuations - small deviations from statistical equilibrium, also fluctuations is incidental changes to the system. The magnitude and direction of fluctuations determines the possible trajectory of exit system from unstable state. Random external action can reinforce fluctuations and guide the system to the choice of further development trajectory. The small fluctuation can grow in macrostructure. According to fluctuations the system chooses the path of further evolution [3].

Attractor means relatively stable structures which result in the evolution in open non-linear environments. They are real structures, so they are called structure-attractors that have the potential inherent in the environment (system) and are defined by the non-linear properties of environment. When system chooses a path of evolution and enters to one of structure-attractors all other evolutionary paths are closed [2]. However, in the course of evolution may be changed the intrinsic properties of the medium, as a result the whole field of possible ways is reconstructed. Therefore, some goals may never be realized. Open systems have many sophisticated ways of evolution, which detect the presence of a large number of forms. Certain conditions can realize one possible form of organization that adequate of self-structure of system. The yield to this structure is determined by the principles of sustainable development most of the process [10].

One of the most important terms of synergetics is a term “bifurcation” which relates to the behavior of complex systems in highly non-equilibrium states. The theory of dynamical systems describes the system using a “phase space” – the set of all possible states in which the system can be. The system can respond to some of the "attractors", forcing the system to grow along certain “paths" in the phase space. When the system goes beyond certain limits, it goes from one family of attractors to other attractors. Thereby the system behavior is changed. This means that a "system transits into a new dynamic mode”. At this point there is bifurcation. The term "bifurcation" refers to the transition of the system from the dynamic regime of the family of stable and simple attractors, to the dynamic regime of more complex and "chaotic" attractors [6].

Bifurcation can be "soft" if the transition is smooth and continuous; "Disastrous" if the transition occurs abruptly and under the influence of attractor that defines regime; and "explosive", if the transition is effected by a sudden change of discrete factors. After the transition to the new regime the system can respond to new attractors, which establish a new order in the system. If the system overcomes the threshold of stability, it is entering a phase of chaos. Chaos could destroy the system, or may lead to a new development. In viable systems chaos generates higher forms of order. Chaos in the philosophical sense is a mess. The opposite of chaos is the order. But in the physical sense it's not a mess and it's not the opposite of order. Chaos in complex systems is always relative. It has a relative measure of randomness and ordering. Chaos has some degree of organization and a structure. Such chaos is deterministic and dynamic. The emergence of bifurcation generates non-linear and intermittent process of evolution of non-equilibrium systems [8]. The result of bifurcation is determined by the interaction of random fluctuations in the chaos of the destabilized critical systems. In this case it doesn't matter neither the history of the system nor environment. If fluctuations, suddenly

become "centers of crystallization" they quickly grow and spread to the entire system. They subordinate the dynamics of the system in a short time. The new order reflects the structural and functional features of the fluctuations, which became the “centers of crystallization”.

Social-economic systems are complex and unstable; and their evolutionary path concerned with bifurcation. These systems are subject to phase transitions. Bifurcation more evident if the system is close to the threshold of sustainability, i.e. if the system is "in danger." Society as a system has an important feature that the bifurcation is not always accidental. Critical situations create people who often understand the nature of the process and can manage this process. This fluctuations interaction is shifted in the right direction which otherwise accidentally. The society can develop alternative behaviors, innovate, creates social and political movements. When the views and practices become obsolete, society begins the search for more functional and effective ideas. Instability in the community can be of various types: T-bifurcation occurs due to poor application of technological innovations; C-bifurcation is generated by external and internal factors; E-bifurcation is associated with changes in the economic and social order under the influence of crisis. Instability can be extended to all sectors and segments of society and cause rapid and profound changes. In most cases, the bifurcations in society are a combination of T and E-bifurcations. Socio-economic systems are open under the influence of flows of information, technology, commerce and global flows of people. These systems are becoming increasingly global.

Countries that seek to modernization often have the skills, values, behaviors and institutions, the structure of production, distribution and consumption that cannot cope with this task. Global flows often serve for a small group of people that becomes "Europeanized" and "modernized", while others people continue to live in the same conditions. This leads to severe disappointments. As long as the political system is stable, and leadership is authoritarian, repression and deception create a semblance of stability. But once the dictatorship collapses, the situation becomes explosive. Frustration creates a breeding ground for reforms that turns into a revolution. Society becomes chaotic, and his behavior – unpredictable [6].

In synergetics the term “development” understood as a series of long periods, corresponding to the stable state of the system, which interrupted bifurcation - short periods of chaotic behavior. The system then moves to the next stable state - attractor, the choice of which is determined usually by fluctuations in the bifurcation point. In the bifurcation points the number of actual scenarios always limited and if events entered one of the modes, the system is changing irreversibly towards the appropriate final state [5]. In socio-economic systems the attractors can serve as universal values and ideals. Crucial social justice is among them.

The process of modernization of socio-economic system is always associated with the introduction of new technologies. Technological support of development is a prerequisite for changes in the economic and social order. Nowadays the determining factor of the development is its information support. The process of information gives push to the development of not only social and economic systems, enterprises and organizations, but also human personality, individuality. Through the development of people, organizations, the models of their behavior, and then and relevant institutions is formed the way to modernization of the whole country and society.

Development of synergetics made it possible to expand the concepts of information and information system. Because the process of self-organization of social system selects bifurcation points, the formation of a new structure occurs out of chaos with generation of information. There are mechanisms for creating information such as memorizing random and "an act of free will" - creating a new, that you cannot predict. Both methods are used for creating information if this process is implemented. "An act of free will" is associated with rational choice and he in turn uses the experience, i.e. memorizing random choice which is earlier happened.

Modern management information systems are man-machine systems. They provide information for the persons that make decisions. A person who makes a decision during the

processing of information is its central element, so the human role in the management process, supported by the information system is crucial. The person who carries decision making performs certain procedures of information processing. Information system provides information. The person also is a carrier of information. Therefore an important role in the decision-making process plays qualification, experience and intuition of a person. People are an important source of information [7].

The scientific base of creation, operation and development of information systems is founded on a systems approach, which is based on the review of the object as a system, as the holistic set of interrelated elements. To study complex systems in system approach we use the "black box" model. When using this model the external observer can monitor the inputs and outputs of the system, and the system structure and internal processes are unknown to him. Conclusions about the behavior of the system are made by means of monitoring the reactions of the output values with change the input. This approach makes it possible to study systems with unknown structure and very complex systems. This method is appropriate to use for the research of information support of government bodies, because it presents the structure and function of complex information systems. These systems are composed of functional subsystems and support subsystems and are linked with information streams, arrays and with operations of information transformation, interaction and subordination. The study of approaches to research information support of the government show that research of systems from a systems perspective and synergy have some differences. Analysis of these differences is provided in the article by Knyazeva E.N. and Kurdyumov S.P. "Synergetics as a new vision of the world: dialogue with I. Prigogine" [4]. However, this analysis, in our view has some flaws regarding the consideration of information systems. The differences that exist in these approaches from the point of view of the authors are given in the table.

Table

The differences in approaches to research from point of view the system approach and synergetics

System research	Synergetics
1. Attention is focused mainly on the functioning of the system.	1. Attention is focused on the development of the system.
2. Equability seen as a condition for the efficiency of the system	2. Nonequability and chaos are considered as factors that create new opportunities for development
3. The processes of an organization are being studied.	3. The processes of selforganization are being studied.
4. On the linear thinking are based.	4. On the nonlinear thinking are based.
5. Internal relationships are being studied, interactions of system with the environment are presented by the input and output streams	5. The internal and external relationships of the system are being studied.
6. A source of changes is located within the system.	6. A source of changes to a greater extent is determined by the external environment
7. The current and future states of the system is determined by its past	7. There are several alternative ways of development
8. The effectiveness of a management is determined by its power.	8. Management efficiency is determined by the resonance effects on the complex systems. These effects are small but properly organized.
9. A negative feedback is used.	9. A positive feedback is used.

The development of the management of the economy is based on the principle of decentralization, according to which more powers should be transferred to lower levels of government. In this case the synergetics allows setting relationships between individual decisions that are made by leaders at the micro level with the processes at the macro level. Decentralization of management, in addition, creates a problem of interaction of state bodies and local self-government with other organizations and citizens by increasing the number of centers of system activity which collect and analyze information to make decisions. All these

processes at individual centers of activity can be seen as fluctuations, small deviations from statistical equilibrium, which in turn create bifurcation points where the system becomes unstable and can have a number of development options. The aim of a manager is to determine path out of the unstable situation and access to the attractors that allow realizing one of the possible forms of organization that is adequate to self-structuring of the system. Important in this process is that the system cannot impose ways of development that do not correspond to its own tendencies. Any decision is connected with the solving of a situation that takes place in the facility management and creates non-equilibrium of the state of the system [1]. Nonequability and deterministic chaos are factors that accompany the decision-making processes. Uncertain situation creates more chaos in the system [9]. Comparison of system approach and synergetics indicates the different views on streamlining processes in the system. From the point of view of system approach the management impact is corrective. It changes the system in the direction of returning to the normative process, in case of deviation. This impact has an organizing effect and establishes the order with using procedures for optimal decision making, for efficient overcoming of resistance to change that occurs in any active intervention to the system. Self-organization is associated with the occurrence of agreed processes, ordering items that are caused by internal factors, without external influence.

Improving the quality of governance is achieved by a thorough analysis of situations that need to be solved. Information systems use special methods of economic analysis, methods of forecasting and resource allocation. An important issue that requires the use of modern information technology is mutual decision making at different levels of government system. These mutual solutions should be carried out at all levels, including at the local level. The use of secure communication channels, which are involved in the information system, can reduce the differences in approach to solving one problem at different levels of the hierarchy. The information systems also allow improving workflow in government bodies, institutions, enterprises, organizations. One of the most significant problems in the workflow in organizations of different levels of the hierarchy is the duplication of information. The reason for this phenomenon is the scheme of transfer of information from one organization to another. This scheme requires the placement of the same data in messages that are sent to different recipients. For solving this problem it is necessary to create integrated distributed databases on different levels of the hierarchy that are available to all users who have access.

The point of bifurcation characterizes the moment when the civil servant must solve problem. These decisions are made at all levels of public administration. The result of the introduction of new solutions causes the fluctuations that determine the new point of bifurcation. This process occurs horizontally - at the appropriate level hierarchical system, and vertically, which provides coordination of different levels. The errors on the low levels of hierarchy can lead to further errors at higher levels, due to fluctuations from the bottom up. The errors on higher levels impact the processes in the society in the form of fluctuations, which extend from the top down. This confirms the concept of e-government that by integrating different information systems will improve the coordination of activities at all levels of government.

The results of analysis of the synergetics concept and bifurcations in the social-economic system and its information component can formulate the main features of the synergistic approach to information support of management of this system. It is in deep self-knowledge of complex, non-linear, open systems, which are the subjects and objects of governance through collection, analysis and dissemination of information; identifying ways of further development of information society and decision-making process, contributing to this development; ensuring the structural changes in the socio-economic system.

Conclusions and suggestions. The results of analysis of bifurcations and management processes with using of the system approach and synergetics gives reason to draw conclusions about the main principles for the synergistic approach in the management of socio-economic

systems. They are: self-organization as for the subject of management and object of management, which has an informational character; openness of management, which through information sharing in a network flows provide interaction of all components of social-economic system; the presence of nonlinearity, which manifests itself in of multiple, cyclical phenomena and resonance, due to the diversity of the information environment; the chaos as both constructive and destructive phenomenon, which allows analysis by socio-economic information in management and to develop effective solutions to ensure the development of institutions that are relevant for a given socio-economic system; the existence of fluctuations, which lead to deviations from equilibrium statistical information which is necessary to collect, analyze and distribute for management in order to identify development trends; existence of bifurcation points, leading to changes in the system and is an important element of decision-making that based on the information on the state of developing, analyzing decision options and chooses the most favorable decisions in terms of solving the existing problems.

References

1. Bushev Michael (1994). *Synergetics: Chaos, Order, Self-Organization*. Singapore a.o.: World scientific, XYI.
2. Haken, H. (1993). *Advanced Synergetics: Instability Hierarchies of Self-Organizing Systems and Devices*. New York: Springer-Verlag.
3. Haken, H. (1983). *Synergetics, an Introduction: Nonequilibrium Phase Transitions and Self-Organization in Physics, Chemistry, and Biology*, 3rd rev. enl. ed. New York: Springer-Verlag.
4. Knyazeva, H.N., Kurdyumov, S.P. *Synergetics as a new vision of the world: dialogue with I. Prigogine*. Retrieved from http://filobiblon.narod.ru/PROEKT/SINERGETIKA.html.
5. Knyazeva, Helena. *What is synergetics?* Retrieved from http://spkurdyumov.ru/what/what-is-synergetics/.
6. Laszlo Ervin (1991). *The Age of Bifurcation. Understanding the Changing World*. OPA (Amsterdam) B.V.
7. Oliychenko, I., Ditkovska, M. (2015). Synergetic approach to the management of socio-economic development of the region. *Problems and prospects of economics and management,* no. 4 (4), pp. 243–248.
8. Prigogine, I, Stengers, I. (1997). *The End of Certainty Simon and Schuster*.
9. Prigogine, I. *The Behavior of Matter Under Nonequilibrium Conditions: Fundamental Aspects and Applications*: Progress Report for Period April 15, 1990 – April 14, 1991.
10. Urry, John (2003). *Global Complexity.* Cambridge: Polity Press.

Oliychenko Igor – Doctor of Public Administration, Professor, Professor of the Department of Management and Public Service, Chernihiv National University of Technology (95 Shevchenka Str., 14027 Chernihiv, Ukraine).
Олійченко Ігор Михайлович – доктор наук з державного управління, професор, професор кафедри менеджменту та державної служби, Чернігівський національний технологічний університет (вул. Шевченка, 95, м. Чернігів, 14027, Україна).
Олейченко Игорь Михайлович – доктор наук по государственному управлению, профессор, профессор кафедры менеджмента и государственной службы, Черниговский национальный технологический университет (ул. Шевченко, 95, г. Чернигов, 14027, Украина).
E-mail: oimd@meta.ua

Ditkovska Maryna – PhD in Public Administration, Associate Professor, Associate Professor of the Department of Management and Public Service, Chernihiv National University of Technology (95 Shevchenka Str., 14027 Chernihiv, Ukraine).
Дітковська Марина Юріївна – кандидат наук з державного управління, доцент, доцент кафедри менеджменту та державної служби, Чернігівський національний технологічний університет (вул. Шевченка, 95, м. Чернігів, 14027, Україна).
Дитковская Марина Юрьевна – кандидат наук по государственному управлению, доцент, доцент кафедры менеджмента и государственной службы, Черниговский национальный технологический университет (ул. Шевченко, 95, г. Чернигов, 14027, Украина).
E-mail: oimd2@meta.ua

Oliychenko I., Ditkovska M. (2016). Bifurcation and synergetic approach to the management of socio-economic systems. *Problems and prospects of economics and management*, no. 4 (8), pp. 38-43.