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COMPLEXITY THEORY IN MANAGEMENT

TEORIA ZŁOŻONOŚCI W ZARZĄDZANIU

Abstract: Complexity theory is an interesting complement to classic scientific theories. Although this topic is at the center of interest of a large group of researchers, there are only a few publications on this subject that can be found in Polish literature. The aim of this article is to fill this gap partially. Basic assumptions of complexity theory have been discussed. Examples of its applications in social and economic sciences as well as numerous applications in other areas have been analyzed. Particular attention was paid to the possibilities of practical application of elements of this theory in the management of complex business systems. The benefits resulting from the development of complexity theory were also shown.

Keywords: complexity theory**,** complex systems, management

Streszczenie: Teoria złożoności (TZ) jest ciekawym uzupełnieniem klasycznych teorii naukowych. Chociaż tematyka ta znajduje się w centrum zainteresowań sporej grupy badaczy, mało publikacji na ten temat możemy znaleźć w literaturze polskiej. Celem artykułu jest częściowe wypełnienie tej luki. Omówione zostały podstawowe założenia TZ oraz przykładowe jej zastosowania w naukach społecznych i ekonomicznych, jak również liczne zastosowania w innych dziedzinach. Szczególną uwagę poświęcono możliwości praktycznego zastosowania elementów tej teorii w zarządzaniu złożonymi systemami biznesowymi. Pokazano także korzyści wynikające z rozwoju TZ.

Słowa kluczowe: teoria złożoności, systemy złożone, zarządzanie

Introduction

Complexity theory (CT), also called in some Polish-language sources complexity science[1], has its roots in disciplines such as biology and sociology, but its connections with management were also quickly noticed. In organization and management sciences this theory has appeared for about 30 years, but knowledge on this subject is still developing[2]. Economic processes and phenomena are certainly not simple. Enterprises, and especially business networks or individual markets can certainly be treated as complex systems.

Complex systems consist of a large number of diverse units – agents with their own intentionality, each of whom has the opportunity to choose from many directions of action[3]. They are parts of a dynamic, complex structure that affect each other[4]. Agents learn and are open to new ideas. This affects their behavior in decision making processes. As a result, the system opens to behaviors that can be effective[5].

The purpose of this work is to answer the question about the possibilities of using CT in management and the benefits that can be achieved through its application in this field. The desk research method was used to collect and organize basic information about CT. A review of scientific and popular science literature was carried out. As part of the introduction, the basic concepts of CT and examples of its applications in various fields were presented. CT was then analyzed in relation to

[1] J. Rokita, A. Dziubińska, *Systemy złożone w zarządzaniu*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice 2016, p. 11.
[2] S. Saygan, *Complexity Theory in Organization Science*, "Ege Academic Review" 2014, vol. 14(3), p. 413.
[3] M. Mason, *Is Thorough Implementation of Policy Change in Education Actually Possible? What Complexity Theory Tells Us About Initiating and Sustaining Change*, "European Journal of Education" 2016, vol. 5(4), p. 437.
[4] M. Mason, *Is Thorough Implementation of Policy Change in Education Actually Possible? What Complexity Theory Tells Us About Initiating and Sustaining Change*, "European Journal of Education" 2016, vol. 51(4), p. 439.
[5] J. Rokita, A. Dziubińska, *Systemy złożone…*, p. 41.

management. Numerous examples of the use of elements of this theory in social and economic sciences have been shown. Particular attention has been devoted to the practical application of CT in organization management. The utility of CT from the point of view of social and economic sciences and the possibilities of its practical applications in complex business systems were analyzed. In addition, attention was drawn to the risks arising from the development of this theory.

1. Complexity theory

CT deals with the behavior of complex systems. These systems are a kind of whole, consisting of a large number of elements, interrelated by non-linear dependencies and operating according to specific rules[6]. Non-linear relationships are otherwise disproportionate, which in extreme cases can be observed as the so-called butterfly effect – a small change can cause huge effects. Simple examples of complex systems are a school of fish or a flock of birds. Parts of the system, so-called agents, interact with each other. The interaction of elements in the system can cause surprising new system behaviors that can be explained by formal models, even if these models cannot predict the evolution of the system[7]. Intentional or accidental interactions between agents cause certain behavioral patterns to emerge. The phenomenon of extinction as well as the complexity itself are the subject of research. The complex system evolves in an evolutionary manner and is able to adapt to both internal and external changes.

Thus, CT deals with networks of units that form a complex whole. It focuses on the model description of phenomena in which particles, micro-phenomena, neurons, people or companies self-organize into team structures[8]. This trend uses metaphors to describe the observed phenomena, while qualitative methods are usually used for research[9]. In contrast to mathematical models, with which usually some parts of reality are described in a simplified way, the science of complex systems tries to look at the studied phenomena as a whole. Mathematical models are an idealized image of reality, they capture the impact of only a number of factors considered important by the model's creators. Some qualitative factors are very difficult to measure, so they cannot be included in the mathematical model[10]. Therefore, a holistic approach to research seems to be a valuable complement to the current

[6] M. Tarasiewicz, *Teoria złożoności jako podstawa budowy elastycznej organizacji*, „Zeszyty Naukowe Wałbrzyskiej Wyższej Szkoły Zarządzania i Przedsiębiorczości" 2009, vol. 13 (2), p. 147-148.

[7] P. Anderson, A. Meyer, K. Eisenhardt, K. Carley, A. Pettigrew, *Introduction to the Special Issue: Applications of Complexity Theory to Organization Science*, "Organization Science" 1999, vol. 10(3), p. 233.

[8] B. McKelvey, *Complexity Theory in Organization Science: Seizing the Promise or Becoming a Fad?*, "Emergence" 1999, vol. 1(1), p. 5.

[9] J. Rokita, A. Dziubińska, *Systemy złożone…*, p. 19-23.

[10] Z. Pierścionek, *Praktyka optymalizacji w przemyśle*, Państwowe Wydawnictwo Naukowe, Warszawa 1986, p. 144.

approach.

Although CT applies to complex systems, it cannot be equated with systems theory. In fact both theories have contributed to the recognition of the roles of individuals and subunits in the survival of an organization, both focus, among others, on the learning of the organization through the interaction of subunits and the environment in responding to chaotic or complex situations, but systems theory focuses on structures, relationships and interdependencies between elements, while CT refers to heterogeneity in different organization subsystems and how parts at a sub-level in the system affect the emerging behavior and outcome of the system[11].

CT is used in various fields. One of its typical applications is its use in education, for example in teaching medicine[12], in examining differences in teacher practices[13], or explaining best practices in simulation education[14]. D. Osberg and G. Biesta associate complexity theory with politics in education[15], and M. Mason with the philosophy of education[16]. A group of articles is analyzing the use of CT in healthcare and medicine, for example, the use of CT to investigate balanced responses to violence on the part of a healthcare partner[17], or linking this theory to clinical practice[18].

Some applications of CT are particularly surprising, for example O. Silva, E. Dornelles Alves and M.C. Soares Rodrigues refer in their research to poetic reflection inspired by this theory[19], while Z. Demjén claims that a fuller understanding of conversational humor can be achieved by conducting at least a few studies on this humor from a CT perspective[20].

2. Complexity theoty in management sciences

CT is an interesting complement to classic management theories and paradigms. Due to the increasing turbulence of the business environment, the speed of

[11] F. Amagoh, *Systems and Complexity Theories of Organizations*, [in:] A. Farazmand (ed.) *Global Encyclopedia of Public Administration, Public Policy, and Governance*, Springer, Cham 2016, p. 1 and 6.

[12] T. Fenwick, M.A. Dahlgren, *Towards socio-material approaches in simulation-based education: lessons from complexity theory*, "Medical Education" 2015, vol. 49(4).

[13] S.D. Martin, S. Dismuke, *Investigating Differences in Teacher Practices Through a Complexity Theory Lens: The Influence of Teacher Education,* "Journal of Teacher Education" 2018, vol. 69(1).

[14] G.C. Townsend, M. Kim, D. Sankey, *Embracing complexity theory can clarify best practice frameworks for simulation education*, "European Journal of Dental Education" 2012, vol. 16(1).

[15] D. Osberg, G. Biesta, (Eds.), *Complexity Theory and the Politics of Education*, Sense Publishers, Rotterdam 2010.

[16] M. Mason, *Complexity Theory and the Philosophy of Education***,** "Educational Philosophy & Theory" 2008, vol. 40(1).

[17] C. Gear, E. Eppel, J. Koziol-Mclain, *Utilizing complexity theory to explore sustainable responses to intimate partner violence in health care*, "Public Management Review" 2018, vol. 20(7).

[18] Ibidem.

[19] O. Silva, E. Dornelles Alves, M.C. Soares Rodrigues*, Lyricism and a touch of art for the aesthetic of nursing knowledge production – a poetic reflection inspired by the Theory of Complexity*, "Cultura de los Cuidados" 2014, vol. 18(39).

[20] Z. Demjén, *Complexity theory and conversational humour: Tracing the birth and decline of a running joke in an online cancer support community*, "Journal of Pragmatics" 2018, No. 133, p. 93.

changes occurring in it and their unpredictability, the classic behavior of managers is becoming less and less effective in the modern environment[21].

We can observe complex systems at various levels. Such a system may be, for example, an enterprise in which the agents are employees or individual departments; it can be an organization's network in which its members are agents; it can be a specific market where agents are entities operating on it; finally, the complex system is the global economy and the agents of the economy of individual countries. The features of a complex system have a business ecosystem, which sometimes includes hundreds of organizations interacting and operating in a particular environment[22]. S. L. Brown and K. M. Eisenhardt write about the art of continuous change, i.e. the relationship between complexity theory and evolution over time in constantly changing organizations[23].

Complexity in the sciences of organization and management is compared to phenomena occurring in other scientific disciplines, for example, biological adaptation or mathematical theory of chaos[24]. However, scientists relatively rarely deal with non-linear phenomena in an organization. They even have a tendency to model phenomena in a linear way to make them easier to study, and they tend to model the behavior of the community as if it were a set of units with average behavior. Therefore, it is advisable to develop model methods for analyzing complex organization processes[25]. Such attempts are currently underway.

The use of CT in management sciences took place, for example, in the management of natural resources (fisheries, forestry), or more broadly in ecology management, in which the management of natural resources was treated as a learning process[26]. Currently, this theory is used in the study of medical services[27] or the multi-level process of management in healthcare[28].

The interest of scientists in the possibility of using CT in the field of management in the public sector is growing.[29] Three main ideas from the theory of complex systems – dynamics, self-organization and co-evolution, are important from the point of view of public administration research[30]. CT has thus become an important

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[21] M. Tarasiewicz, *Teoria złożoności…*, p. 147.

[22] A. Wilczyński, *Znaczenie teorii złożoności w ekosystemie biznesowym*, „Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" 2011, vol. 2(168), p. 378.

[23] S.L. Brown, K.M. Eisenhardt, *The Art of Continuous Change: Linking Complexity Theory and Time-paced Evolution in Relentlessly Shifting Organizations*, "Administrative Science Quarterly" 1997, vol. 42(1).

[24] J. Rokita, A. Dziubińska, *Systemy złożone…*, p. 23.

[25] P. Anderson, A. Meyer, K. Eisenhardt, K. Carley, A. Pettigrew, *Introduction to the Special Issue: Applications of Complexity Theory to Organization Science*, "Organization Science" 1999, vol. 10(3), p. 233.

[26] J. Rokita, A. Dziubińska, *Systemy złożone…*, p. 21.

[27] K.M. Long, F. McDermott, G.N. Meadows, *Being pragmatic about healthcare complexity: our experiences applying complexity theory and pragmatism to health services research*, "BMC Medicine" 2018, vol. 16.

[28] N. Touati, L. Maillet, M.A. Paquette, J.L. Denis, C. Rodríguez, *Understanding Multilevel Governance Processes through Complexity Theory: An Empirical Case Study of the Quebec Health-Care System*, "International Journal of Public Administration" 2019, vol. 42(3).

[29] E.A. Eppel, M.L. Rhodes, *Complexity theory and public management: a 'becoming' field*, "Public Management Review" 2018, vol. 20(7), p. 949.

[30] E.H. Klijn, *Complexity Theory and Public Administration: What's New?: Key concepts in complexity theory compared to their counterparts in public administration research*, „Public Management Review"

theoretical tool for understanding management in this sector[31].

As one can see, CT can be used in economics in many areas. Treating an organization as a non-linear complex system can give a new perspective on the possibilities and methods of controlling organizational behavior[32].

3. Complexity theory in management

The attention paid to CT is growing as a potential management tool[33]. Attempts have been made in the literature to translate the theoretical assumptions of CT into practice. For example, D. Okes provides specific principles by which this theory can be used to manage an organization. In his view, it should be ensured that the mission, values, goals and priorities of the system are clear; provide only as much control as is necessary for the system; make sure that we have enough feedback so that the system can detect and respond to signals, indicating the need for change; one needs to monitor a wide range of system performance indicators to better understand how well an organization works; one also needs to make many small changes rather than serious interference to improve system performance[34].

Developing research on the use of CT in management sciences has led to attempts to apply this theory in practice. It even became a kind of fashion. This was probably due to pressure on managers who are required to have an innovative approach and the enthusiasm with which management consultants are implementing scientific concepts, although these are not yet sufficiently tested. It must be taken into account that the direct translation of the complexity of physical and natural sciences into management sciences can cause distortion[35]. Nor should CT applications be identified in management sciences using this theory in management practice.

In CT strategy is not imposed from above. Only certain general rules of conduct are set out. It is assumed that as a result of the activities of individual cells within the framework defined by simple, general rules, the strategy will develop somewhat from the bottom up. The strategy emerges along with the actions taken by the agents, which then lead to interaction. It emerges on the one hand from practical activities, and on the other hand as a result of the thought process of the agent-inventor[36].

CT suggests that organizations should be able to configure themselves to meet changing needs, because self-organizing processes facilitate the emergence of a new order. However, there is a contradiction here between the concept of naturally occur-

2008, vol. 10(3), p. 299.

31 Y. El-Ghalayini, *Complexity Theory: A New Way to Look at New Public Management,* "Network and Complex Systems" 2017, vol. 7(1), p. 6.

32 M. Tarasiewicz, *Teoria złożoności…*, p. 151.

33 A.C.T. Smith., C.E. Humphries, *Complexity Theory as a Practical Management Tool: A Critical Evaluation*, "Organization Management Journal" 2004, vol. 1(2), p. 91.

34 D. Okes, *Complexity theory simplifies choices*, "Quality Progress" 2003, vol. 36(7), p. 35-36.

35 B. McKelvey, *Complexity Theory…*, p. 5-6.

36 J. Rokita, A. Dziubińska, *Systemy złożone…*, p. 180.

ring self-organizing processes and the need for managerial intervention in positioning an organization[37]. CT assumes that order, and in particular new orders, may emerge from chaos. Facilitating chaos seems to be an imprudent strategy in any organization[38]. Therefore, direct application of this theory in practice seems to be of little use.

Nevertheless, CT gives companies other options, namely the epistemological use[39]. It helps to understand processes that accelerate or strengthen changes[40]. In other words, it applies in explaining how change evolves and why it is not linear. It gives the opportunity to interpret various organizational behaviors and discourages managerial interventions in the form of excessive control and regulation. However, the practical utility of this type of thinking is definitely exaggerated[41].

The situation is different in the case of such systems in which we deal with many independent agents. As an example, we can give the economy of a given country. Here, the government has no direct influence on the decisions taken by individual enterprises, but through its actions it can set a general framework and support certain development directions. For example, if preferences regarding innovation or internationalization of enterprises are introduced, then the economy may behave like a typical complex system and bottom-up activities of individual companies, as well as interactions between them may lead to the expected effects, although the paths to reach them have not been specified top-down. A similar situation occurs in such networks of enterprises, in which the partners are autonomous, independently strive to achieve their own goals, and the structure (formalized or not) on the one hand helps them to develop, and on the other grows as an organization. In such networks, we can also deal with the emergence of some solutions typical of a complex system.

Summary

We can see that the interpenetration of scientific theories between different disciplines is now a growing trend. This impact can be multidirectional. While the use of mathematical models to describe economic or natural phenomena seems to be something natural, describing the functioning of an organization based on observations made in biology for example, seems surprising.

However, looking at management from the point of view of CT and at enterprises or their networks as complex systems, allows for interesting observations.

[37] R. MacIntosh, D. McLean, *Conditioned emergence: A dissipative structures approach to transformation*, "Strategic Management Journal" 1999, No. 20(4), p. 310.
[38] A.C.T. Smith., C.E. Humphries, *Complexity Theory…*, p. 102.
[39] B. McKelvey, *Complexity Theory…*, p. 5-6.
[40] P. Salem, *Assessment, change, and complexity*, "Management Communication Quarterly" 2002, vol. 15(3), p. 448.
[41] A.C.T. Smith., C.E. Humphries, *Complexity Theory…*, p. 99.

The phenomena occurring in enterprises or organization networks can often be explained using this theory. However, one should not uncritically strive to use CT in management practice because we can encounter many difficulties here.

The study has some limitations, the basic one is the size of this work, which forces the author to raise only the most important, basic aspects of the topic discussed. It is advisable to conduct further research on the use of CT in economics and management sciences. The answer to the question of whether and in which situations CT can be used in management practice is particularly important.

Nevertheless, CT can make a significant contribution to the development of science. It gives the opportunity to explain many phenomena. The results of research on complex systems and future applications of CT will surely surprise us more than once.

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