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Cognitive Technologies in Management

INTRODUCTION

Computers cannot think. However, they can increasingly do things only humans were able to do. It is now possible to automate tasks that require human perceptual skills, such as the recognition of handwriting or face identification and those that require cognitive skills, such as planning, reasoning based upon partial or uncertain information and learning. Technologies able to perform tasks such as these, traditionally assumed to require human intelligence, are known as cognitive technologies [Schatsky, 2015]. The increasing use of such technologies gives rise to the phenomenon known in modern science and practice as cognitive management.

Nowadays obtaining reliable information and operational analysis are important prerequisites for successful management. The socio-economic system, as an object of control, is a complex set of processes and factors that actively interact

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with each other as they are made up of subsystems that are capable of self-organization. The modeling of such systems is based on theories of evolutionary economics [Wysocki, 2010].

The traditional method of management is seen as the process of finding an optimal solution from the set of available alternatives in order to achieve the goal (optimization criterion) [Tools and Techniques…, 2012]. As such the purpose of the system – the set of all alternatives, is strictly defined and described by the relevant quantitative parameters. However, the socio-economic system is characterized by uncertainty due to the lack of information about possible states of the system in terms of uncontrolled and unstable environment. One of the main problems is the formalization of fuzzy management knowledge. Another problem that arises during developing of management models is a qualitative nature of information (assumptions, concepts, problem situations, etc.).

Thus, management of socio-economic systems is a complex intellectual process, which is required to support new approaches to learning and formation of economic knowledge. Today's effective management tool is cognitive technology. The methodology of cognitive analysis involves the development of formal models to support intelligent process control. Cognitive science began as a theory of cognition [Tools and Techniques…, 2012]. This trend which was shaped around the turn of the twentieth century, states that any social activity can be interpreted as the result of cognition – the acquisition of knowledge.

This approach was quite natural in such sciences as psychology, sociology and linguistics,. Economists began scientific experiments into the use of cognitive technologies in management during the 60's – of the XX century [Allen et al., 2011]. These works include the following:

- *Elizabeth McMillan (2007) Complexity, Organizations and Change (Routledge Studies in Complexity and Management). Taylor & Francis (March 14, 2007)*
- *Michael R. Lissack (2002) The Interaction of Complexity and Management. Praeger (November 30, 2002).*
- *Jamshid Gharajedaghi (1999) Systems Thinking, Second Edition: Managing Chaos and Complexity: A Platform for Designing Business Architecture. Butterworth-Heinemann; 2 edition (May 10, 1999).*
- *J. Davidson Frame (1994) The New Project Management: Tools for an Age of Rapid Change, Complexity, and Other Business Realities (Jossey Bass Business and Management Series) (Jossey-Bass Business & Management). Jossey-Bass; 2 Sub edition (April 30, 1994)*
- *Ralph D. Stacey (2010) Complexity and Organizational Reality: Uncertainty and the Need to Rethink Management after the Collapse of Investment Capitalism, 2nd Edition. T & F Books UK; 2 edition (January 6, 2010)*

One of the fundamental works on the foundations of cognitive technologies was undertaken by U. Neyser [Нейссер, 1998].

THE PURPOSE OF THE STUDY

This paper is devoted to the research into the prospects of using cognitive technologies in management, in particular, to the problems of converting information streams in order to create new knowledge.

At the end of the XIX century and in the XX century, the concept of technology was used in relation to the methods of functioning of material production. In the sixties of the XX century, the interpretation of technology was further refined through the work of futurist and science fiction writer Stanislaw Lem – *The amount of technology*. In his view, the efficiency of business processes and the development of the country is determined by the full range of available technologies – industrial, administrative, educational, political, and others [Лем, 1996, p. 463]. Stanislaw Lem was not only an authority of science fiction but also a philosopher and a visionary of human development.

As a result of the rapid development of information technology, including methods of information influence on individuals and society, research into the impact of reflexive control began towards the end of the XX century. These processes contributed to the growth of virtual reality through computerization, the development of social networking, information exchange, media, modern means of communication and connection. In addition, there was a significant breakthrough in the study of the human brain, around the same period, as well as progress was made in the area of mathematical psychology and sociology. These developments stimulated the spread of the concept of "cognitive technologies" and further aroused the attention of researchers and practitioners to the associated issues.

"Cognition" – the equivalent of Latin *Cognitio* refers to the mental processes of perception, memory, judgment, reasoning and ultimately the process of knowing [*Dictionary*]. In general, cognitive technology relates to the method and algorithms of achievement of different goals by people, companies, political organizations through the use of tools for discovering the world, extended communication, information processing. The basis of cognitive technology is cognitive science which studies how people perceive the world, how they think, what they pay attention to, how they remember information and more. Therefore, cognitive technologies are based on the principles of neuroscience, the theory of synergy (self-organization), the computer, information technology, mathematical modeling of human consciousness and other scientific and practical concepts that were previously considered as the components of basic and applied natural science [Малинецкий at al.].

Cognitive management, in many ways, is based on the concept and development of cognitive computing which involves self-learning systems that use data mining, pattern recognition and natural language processing to mimic the way the human brain works. The goal of cognitive computing is to create automated IT

systems that are capable of solving problems without requiring human assistance [TechTarget].

Thus, the most important factors for introducing cognitive technologies – the availability of required knowledge, financial and organizational support, their distribution in society, particularly through intelligent information sub-systems. In the area of cognitive technologies, unlike many other areas, mankind is at the beginning of its journey, but there is huge potential for development in this area.

The dynamics of many processes that occur in social and economic systems is described by the logistic models. The development of scientific direction (Innovative Technology) described by logistic curve, can be defined by the differential equation

$$\frac{dY}{dT} = k(Y-a)(b-Y) \tag{1}$$

where: T – parameter characterizing the overall cost of the development of a new scientific field (including time spent, generalized social labor, estimated in value terms, etc.); $Y(T)$ – socially significant result that is achieved through the use of scientific knowledge (innovative technology); $k(k>0)$ – proportionality factor (scale factor); $a,b(a>0,b>0)$ – the lower and upper limits, respectively, that limit $Y(T)$, in particular, a – the possibility of initial research direction (technologies), b – technological limit, the highest feasibility of knowledge implementation.

The innovative nature of the scientific field contains an opening – increase of knowledge and the invention – a new way of using knowledge. With increasing costs of establishing and implementing knowledge their technologically significant result will grow, so $Y(T)$ – is a monotonically increasing function in the entire range of definition. The first derivative (rate of change) of $Y(T)$ in the equation (1) is directly proportional to the increase of function $(Y-a)$ in relation to the initial capabilities (general level of knowledge a), so the result will be more significant if the difference will be greater ($Y(T)$ will grow faster) and therefore use of knowledge will be more effective, which in turn will increase the price of innovative technology of given scientific field. On the other hand, the proportion of the first derivative to the values $(b-Y)$ means a slowing growth of $Y(T)$ while coming close to the upper limit.

Let us analyze the effect of logistical mechanisms using cognitive maps as a directed graph, whose vertices are the main factors and the edges represent causal relationships. Relationship $A \to C$ is considered as positive ("+" sign), if the increase of factor A causes a growth of factor C (enhanced impact of factor C), decrease of factor A causes a decrease of factor C in other similar circumstances. The "-" sign means that the relationship is negative, namely in other sim-

ilar circumstances the increase of factor *A* causes a decrease (inhibition) of *C*. If we uncover the brackets on the right side equation (1), we will obtain:

$$\frac{dY}{dT} = k(a+b)Y - k\left(Y^2 + ab\right). \tag{2}$$

As mentioned, the first term of the right part of (2) means that the rate of change of innovative knowledge $Y(T)$ is proportional to achieved results (innovative technology).

The second term allows us to state that the rate of change of $Y(T)$ is inversely proportional to the square of reached innovative utility. Let us denote: A – a factor of the rate of change of innovative results (knowledge); B – factor of available options for achieving results $k(a+b)Y$; C – factor of achieved innovative result $Y(T)$ level; D – factor of influence of cognitive processes of accumulation $-k\left(Y^2 + ab\right)$. Cognitive map of logistical mechanisms of scientific innovation is directly shown in Fig. 1.

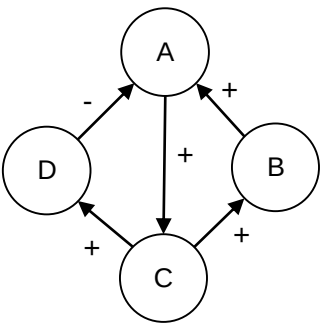

Fig. 1. Cognitive map of logistical mechanisms of scientific innovation

Let us consider the interaction of factors. Effects of the right contour $ACBA$ cause the exponential growth of innovative results. Left contour $ACDA$ displays negative feedback, which stabilizes the process at the level of saturation b. The dynamics of the process is determined by the alternating dominance of contours. First, until the process reaches the mid $Y = (a+b)/2$, contour of positive relationship $ACBA$ is dominating. After passing a given point, the dominant influence has the contour of negative communication $ACDA$.

The differential equation (1) is a dynamic model of logistic evolution (S-curve) – the law of mutual transformation of quantitative and qualitative changes in relation to accumulation of potential of the research direction, because of the influence of cognitive processes.

Cognitive management provides qualitatively new tools of human resource management, combining the capabilities of personnel management and strategic management for effective development of organizations [Cicmil et al., 2009].

The main problem arising in the management of an organization is its effective functioning and development. The inefficiency of the production structure causes significant losses until the end of activity. It was established, that the main problem factors for any organization are: competition (A); quality of products or services (B); image of the enterprise (C); advertising campaign (D); demand for goods and services (E); human resources (F); current assets (G). To solve the problem generalized cognitive map of efficiency of functioning of organization was built Fig. 2.

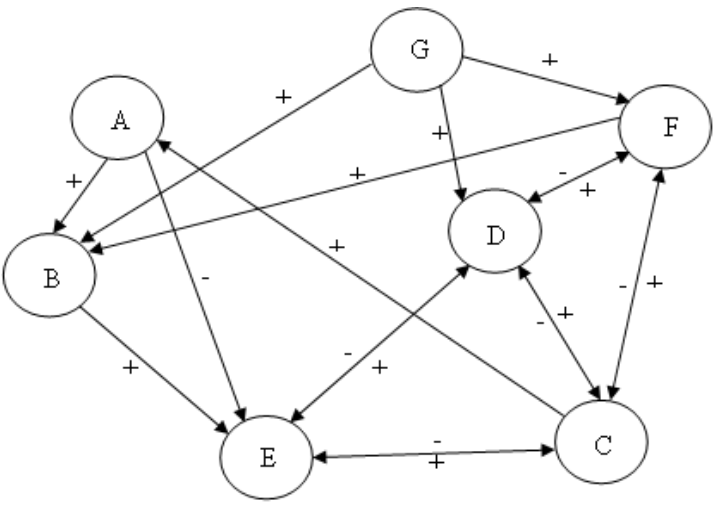

Fig. 2. Generalized cognitive map of efficiency of functioning of organization

Let us consider the interaction of factors in the contour $D\,C\,E\,D$. Suppose that advertising campaign was successful. This will positively affect the image of the organization, which, in turn, will increase the demand for goods and services, and also will enhance advertising company.

In contour $D\,C\,E\,D$ all curves are positive ("+"), obviously an increase of any factor in this contour will be enhanced (contour increases deviation as it does not contain negative connections). Contour $D\,E\,C\,D$ will also enhance rejection, but the negative impact of relevant factors, since all curves are negative ("-"). These contours cause synergistic effects.

This scheme of analysis mainly depends on intuitive ideas about causality of relationships of factors. It is clear that the interaction of two factors is subject to more complex patterns. Then it is necessary to use functional dependencies.

Modern management is actively using various tools of cognitive modeling – conceptual diagrams, mind maps, conceptual schemes etc [Eicher, 1996, 12–15]. This makes it possible to identify the real problems and the causes of their appearance in the face of uncertainty and ambiguity of management decisions.

CONCLUSIONS

Acceleration of scientific progress under modern conditions induces a number of fundamental technical changes. We can identify a tendency to spread information and humanitarian technologies which has emerged from the 80's. of XX century, the development of bio – and nanotechnology in recent decades. Against the backdrop of these changes the steady development of cognitive technologies of economy management is particularly expressive.

The cognitive challenge which came into the world on the threshold of the third millennium, stimulates new discoveries in science and practice: acceleration of development of cognitive technologies and cognitive subsystems of economics, transformation of cognitive area into a powerful dynamic management component. The need for realigning to cognitive principles of economy is even more actualized by the urgent changes in the mechanisms of the economic organization at the micro – and macro levels.

Prospects for further research: Edification and generalization of international practice for the use of cognitive control technologies and development of cognitive micro – and macro subsystems of economy and economic governance at the regional and national levels.

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Summary

The article examines the concept of cognitive technologies – its definition, development and intricacies. It further discusses the perspectives for the use of cognitive technologies in management fields and in particular, the problems of converting information streams in order to create new knowledge. Urgent changes in the instruments of economic organizations at the micro – and macro levels emphasize the need for realigning to cognitive principles of the economy.

Keywords: cognitive technologies, cognitive management

Technologie kognitywne w zarządzaniu

Streszczenie

Artykuł analizuje koncepcję technologii kognitywnych/poznawczych – tj. definicje, rozwój oraz złożoność. Ponadto omówiono perspektywy wykorzystania technologii poznawczych w dziedzinie zarządzania, w szczególności problemy przekształcania strumieni informacji w celu kreowania nowej wiedzy. Postępujące zmiany w ekosystemie podmiotów gospodarczych na poziomie mikro i makro, podkreślają potrzebę przystosowania się do poznawczych zasad rynku.

Słowa kluczowe: technologie poznawcze, zarządzanie kognitywne

JEL: C80, L86, O32