Cognitive Technologies in the Regional Economic Security Management

Yuri A. Salikov, Leyla R. Magomaeva, Dzhamiliya A. Sozaeva, Alexey S. Molchan, and Tatiana V. Il'ina

Abstract

The authors proved that the potential of cognitive technologies in solving problems of regional economic security management lies in their ability to model poorly formalized processes, predict their development, and improve the quality of management decisions. Scientific novelty of the research: The author's hypothesis that the process of managing the regional economic security to a new qualitative level is possible through the use of cognitive technologies is substantiated. Potential threats to the well-being of the region's life are revealed. Research methods: theoretical analysis method, systematization method, comparative analysis method, system approach, and cognitive modeling method.

Keywords

Economic security • Region • Management • Cognitive technologies • Threats

JEL Codes

R11 • R13 • R58

1 Introduction

Studies of complex systems, nonlinear dynamics, self-organization processes, as well as human mental capabilities are becoming more and more scientific and practical in terms of ensuring effective management of the life processes of modern society (Johnson, 2010; Malinetsky et al., 2011).

In a turbulent global economy, due to recurring financial, economic, currency crises, and man-made disasters and pandemics, it creates a situation where the governmental bodies are not able to provide the social welfare of their subordinate territories and their economic security.

In this case, it is necessary to use alternative approaches to managing territorial socio-economic systems and ensuring their economic security based on cognitive tools.

2 Theoretical Basis

Researchers often call economy turbulent, that is, subject to regular crises and various instability factors that can cause permanent and long-term fluctuations in the sustainable development of the economic system (Brenner, 2014; McNally, 1999). Turbulence can be caused by fluctuations in currency and financial markets, structural distortions of the economy due to technological development and digitalization, escalating security problems, natural disasters, as well as unjustified decisions in the field of public policy, and so on (Polulyakh, 2017; Zhuravleva & Manohina, 2013). These reasons threaten the well-being of the development of countries and their territories. In the conditions of turbulence in the territorial context, the problem of regional management is updated.

Certain state of the region's economy, where decent conditions for living and development of people are created, socio-economic stability is maintained, as well as, there is a potential to prevent internal and external threats (Edelev,

Y. A. Salikov (✉)
Voronezh State University of Engineering Technologies, Voronezh, Russia
e-mail: saural@rambler.ru

L. R. Magomaeva
Grozny State Oil Technical University named after Academician M.D. Millionshchikov, Grozny, Russia

D. A. Sozaeva
Moscow University for Industry and Finance «Synergy», Moscow, Russia

A. S. Molchan · T. V. Il'ina
Kuban State Technological University, Krasnodar, Russia

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2007; Huber et al., 2010; Kalinina, 2010; Kremlev et al., 2007; Shubina, 2017).

Various technologies can be used to manage the regional economic security. Traditional management technologies (including automated decision support systems), as a rule, do not reflect the mental resource of a person (Punda, 2011). Thus, cognitive technologies allow neutralizing the mental limitations that arise in the process of managing socio-economic systems.

The most common cognitive technologies are cognitive modeling, which allows to effectively study the behavior of systems that are difficult to formalize by using linguistic variables and fuzzy algorithms; drawing up cognitive maps based on methods of fuzzy logic, graph theory, and matrix approach (Azhmukhambedov, 2010; Khrustalev & Makarenko, 2007; Makarenko & Maksimov, 2001).

3 Methodology

The research hypothesis: regional economic security management transit to a new qualitative level is possible due to the use of cognitive technologies.

Purpose: to reveal the possibilities of cognitive technologies, as well as ways to use them to security management in regional economic system.

Research problem:

- Systematize the existing problems of regional development as in Russian regions.
- Identify potential of cognitive technologies in solving the problems of managing the regional economic security.
- Propose a conceptual algorithm for implementing cognitive technologies of regional security management.

Methods of cognitive modeling proposed by Azhmukhambedov (2010), Khrustalev and Makarenko (2007), Maksimov and Karnaushenko (1999) to develop an algorithm for managing the regional economic security based on cognitive technologies.

Research methods: theoretical analysis method, systematization method, comparative analysis method, system approach, cognitive modeling method.

4 Results

Regional specifics determine the emergence of threats that affect the security of a particular region, as well as the state as a whole (Mejokh et al., 2020; Novikova & Krasnikov, 2010). The regional economic security is reflected through its system of indicators:

- Ascertaining indicators for monitoring the state of the region, assessing the degradation of the regional economy structure, as well as the dynamics of overcoming them.
- Growth potential region's development, possibility of overcoming the stagnation state or lagging behind due to internal resources, as well as the growth points design (Pankov, 1992) (Table 1).

Functioning of Russian regions is characterized by turbulence associated with the impact on them of the global crises and the emergence of areas of tension due to the national specifics of development and implemented by the reproductive model: a lack of financial resources to ensure individual economic agents (for example, 80% of all financial resources of the country are concentrated in Moscow, while investment per capita in 2018 in different regions of the Russian Federation between 29,575 rubles (Ivanovo region) and up to 1,897,041 rubles (Yamalo-Nenets Autonomous district) (Federal State Statistics Service of the Russian Federation, 2020); uneven resource distribution, which determines the interregional disproportion in the gross regional product (for example, of the 30% of the total Russian gross regional product produced in the Central Federal district, more than 50% falls on the city of Moscow); an imbalance in the "production-consumption" system (Orlova et al., 2016; Oskina, 2013). In addition, they may be natural (natural disaster) or anthropogenic (technological failure). However, in terms of regional economic security management, it is advisable to systematize threats into objective threats and threats that are subjective.

Within the framework of this classification, the regional management system has a register of objective threats and specific tools for their leveling. For example, in the event of an emergency in the region, financial support is provided to the population to prevent the growth of social tension. If unemployment increases, regional government agencies strengthen educational processes, creating conditions for professional retraining of personnel. If a critically low value of investment and business activity indicators is reached, tax relief initiatives or special tax regimes are launched.

However, the tools for leveling emerging threats in this case are based on traditional patterns of human thinking, and the economic security management system is developed in accordance with the traditional vector, based on the previous experience in regulating such threats. At the same time, many promising areas and effective tools for ensuring economic security in a turbulent and rapidly changing environment remain closed to implementation due to the subjectivity of their perception by people (Fig. 1).

Potential of cognitive technologies to expand the range of tasks related to formalizing numerically immeasurable factors, predicting threats, and improving the quality of

Table 1 Economic security of Russian regions

Type of indicators	Name
Ascertaining indicators	Volume of GRP per capita, % of the average for the "seven"
	Share of food imports in domestic consumption, %
	Depreciation of fixed assets of enterprises, %
	Regional credit organizations, % in the total number of credit organizations in the region
	Population with monetary incomes below the subsistence minimum, % of the total population
	Life expectancy at birth, number of years
	Income differentiation, times
	Crime rate, number per 100 thousand people
	Unemployment rate, %
	Housing affordability (the ratio of its market price to the average annual family income), times
	Suicide rate, number of cases per 100 thousand people
	Employment, %
	Growth rate of consumer spending, %
	Rate of growth in real incomes, %
Growth potentials indicators	Share of investments in GRP,%
	Organizations that performed research and development, units
	Savings-to-investment ratio, times
	Share of foreign investment in total fixed capital investment, %
	Ratio of R&D expenditures in the GRP,%
	Ratio of internal current expenditures for basic research, applied research and development, times
	Ratio of expenditure on technological innovation and spending on research and development (R&D), times
	Ratio of the coefficient of renewal and disposal of fixed assets, times

Source Authors according to Glazyev (1997), Novikova and Krasnikov (2010), Federal State Statistics Service of the Russian Federation (2020)

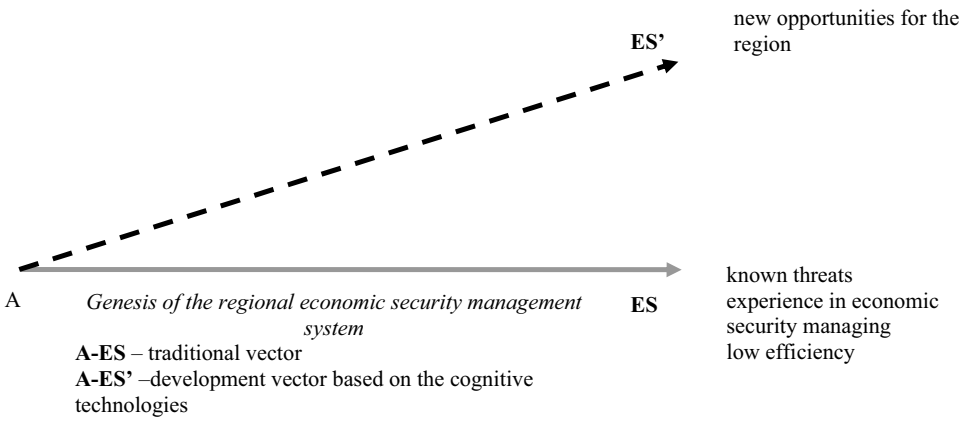

Fig. 1 Regional economic security management system. *Source* Compiled by the authors

management decisions based on incomplete and contradictory information (Azhmukhambedov, 2010; Khrustalev & Makarenko, 2007; Maksimov & Karnaushenko, 1999).

Among the most successfully applied cognitive technologies (Fedulov, 2005; Kosko, 1986; Stylios et al., 1997). The advantages of these technologies are simplicity and visibility, as well as the ability to identify cause-and-effect relationships between elements of a complex system that cannot be evaluated using traditional methods. The results of cognitive modeling can also be presented using automated

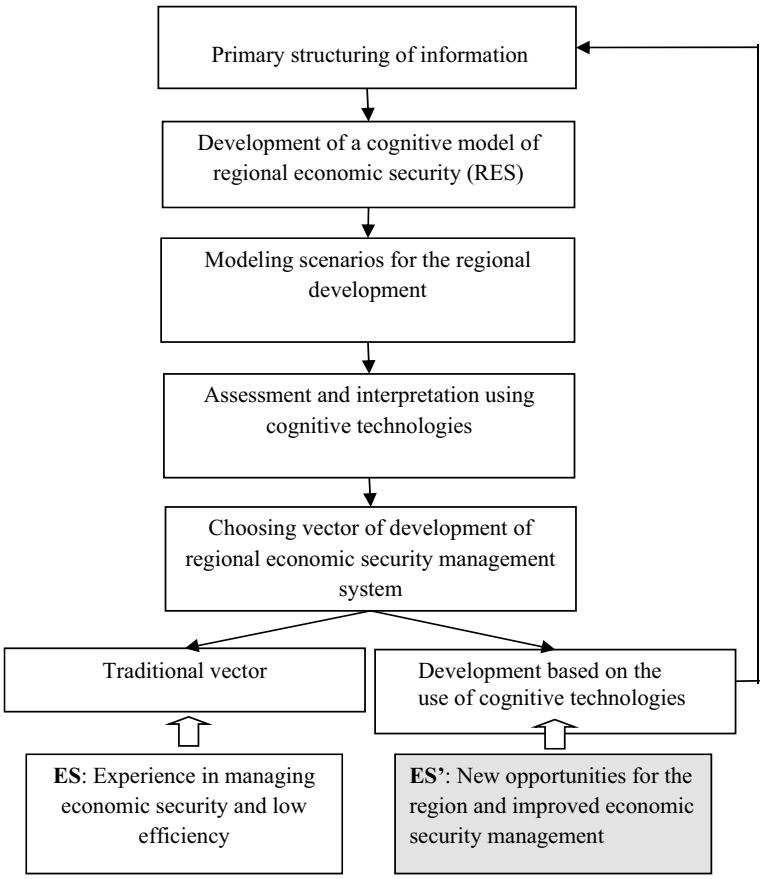

Fig. 2 Algorithm for regional economic security management. *Source* Authors

software packages, such as FCMBuilder (Vasiliev et al., 2014).

Algorithm of actions for managing the economic security of the region based on cognitive technologies is shown in Fig. 2.

First three steps in this proposed algorithm are performed in Table 2.

At stage 4, the effectiveness of management decisions of regional authorities is evaluated by indicators: the level of the goal achievement; the management decisions effectiveness (as a ratio of results and costs). At the same time, as shown in Fig. 1, when the region's economic security management system moves to a qualitatively new level of ES management, new threats appear. For example, in the case of using cognitive technologies at the stage of information structuring and forming a cognitive model of regional economic security, the weak point is the person himself, his ability to conduct high-quality monitoring, and collect information that is processed and analyzed using cognitive tools. In addition, the effectiveness of regional economic security management based on cognitive modeling also remains dependent on the human factor. Given the fact that cognitive technologies are derived from artificial intelligence, if they are used and are justifiably effective, they pose a threat of replacing humans in production processes, that is, the emergence of so-called technological unemployment (Karpunina et al., 2019; Molchan et al., 2019). In addition, some researchers argue that cognitive technologies pose a danger to humans, as they alter human nature, thereby threatening human rights and human identity (Habermas, 2010). Cognitive technologies can also cause a gap between the development of scientific knowledge and the process of moral transformations that regulate social relations at the universal and personal levels (Chernikova & Chernikova, 2012).

5 Conclusions

It is concluded that to bring the process of managing the regional economic security to a new qualitative level, it is necessary to use cognitive technologies that can expand the possibilities of improving the regional management efficiency. The authors proposed a conceptual algorithm for

Table 2 Stages of application of cognitive technologies

The name of the stage	Content	Mathematical formalization
1. Primary structuring of information	Collecting, analyzing, and structuring information about the functioning of the regional economy and the processes that determine its development	• formation of a set of basic factors by the formula: $X = \{x_1, x_2, \ldots, x_n\}$ • determination of the trend of each factor (the growth rate of the indicator), the nature (positive or negative) and the strength of the relationship between them; • representation as a linguistic scale of the values of the variables in the range from −1 to +1
2. Formation of a cognitive model of regional economic security (RES)	The formation of a cognitive model is based on the results of analyzing texts contained in the information and analytical database and questioning/interviewing experts and decision-makers	• building a cognitive RES model using a sign-oriented graph: • formation of a fuzzy cognitive model of a lower level in the form of a matrix of regional economic security: $\text{RES} = \begin{bmatrix} K_1 & F_1 & V_1 & T_1 & S_1 \\ K_2 & F_2 & V_2 & T_2 & S_2 \\ K_3 & F_3 & V_3 & T_3 & S_3 \\ K_4 & F_4 & V_4 & T_4 & S_4 \\ K_n & F_n & V_n & T_n & S_n \end{bmatrix}$ where F_i—vector of change of the i-th criterion (0, +1, −1); V_i—parameters of the rate of change of the i-th criterion; T_i—time for interpreting the value of parameter V_i, typical for the i-th criterion; S_i—negative consequences of implementing threats that worsen the value of the i-th criterion. Each tuple (K_i, F_i, V_i, T_i, S_i) reflects the state of regional economic security according to the i-th criterion •grouping criteria by areas of regional economic security
3.Modeling scenarios	Detection of economic security damage	• division of threats into primary T_i (which do not depend on the state of the region and occur with absolute probability) and secondary T_j (their appearance depends on the internal balance of the region's economy, as well as its external environment) • determining the probability of primary and secondary threats (PT_i and PT_j); • assessment of the impact of primary and secondary threats with a certain degree of probability on the regional economic security matrix RES: $\bar{\imath}_{km}$ and $\tilde{\imath}_{km}$ (where $k = 1, \ldots 3$; $m = 1, \ldots, 5$); * • description of each of the primary or secondary threats by influence matrices using the formula: $I_i = \begin{bmatrix} i_{11} & i_{12} & i_{13} & i_{14} & i_{15} \\ i_{21} & i_{22} & i_{23} & i_{24} & i_{25} \\ i_{n1} & i_{n2} & i_{n3} & i_{n4} & i_{n5} \end{bmatrix}$ • determining the risks of implementing the i-th primary threat with probability PTi using the tuple $R_i = \{I_i; \text{PT}i\}$, which change the state of the region's economic security management system through the corresponding influence matrices I_i; • description using the matrix of preventive measures (where $j = 1, \ldots, M$, M—the number of preventive measures) of the degree of mitigation of the primary threats impact: Some formulas have been removed from the table $P_j = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} & p_{15} \\ p_{21} & p_{22} & p_{23} & p_{24} & p_{25} \\ p_{n1} & p_{n2} & p_{n3} & p_{n4} & p_{n5} \end{bmatrix}$ •formation of a matrix for eliminating the consequences of primary threats in case of ineffective implementation of preventive protection measures: $E = \begin{bmatrix} e_{11} & e_{12} & e_{13} & e_{14} & e_{15} \\ e_{21} & e_{22} & e_{23} & e_{24} & e_{25} \\ e_{n1} & e_{n2} & e_{n3} & e_{n4} & e_{n5} \end{bmatrix}$ •forming a matrix of economic security damages to assess the effectiveness of implementing measures to eliminate the consequences of primary threats: $D = \begin{bmatrix} d_{11} & d_{12} & d_{13} & d_{14} & d_{15} \\ d_{21} & d_{22} & d_{23} & d_{24} & d_{25} \\ d_{n1} & d_{n2} & d_{n3} & d_{n4} & d_{n5} \end{bmatrix}$ •determining the risks of secondary threats to the regional economic security using the formula: $R_j = \{I_j; PT_j\}$

Source Maximov and Kornoushenko (1999), Khrustalev and Makarenko (2007), Azhmukhamedov (2010)

implementing cognitive technologies in the regional economic security management system, as well as presented an extended interpretation of each stage based on cognitive modeling techniques.

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