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Problem formulation of cognitive modeling of industrial investment development of medium-sized and single-industry cities

Formulación de problemas de modelación cognitiva del desarrollo de inversiones industriales de ciudades de tamaño mediano y unindustriales

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Content

ABSTRACT:

The article deals with cognitive modeling problems of industrial investment development of medium-sized and single-industry cities, which make it possible to take a gradual analysis of cognitive modeling structure including an initial idea about the modeled economic system; conceptual scheme formation and cognitive modeling structure on its base; structural analysis of cognitive modeling; system development modeling; scenario analysis; results interpretation; modeling results analysis.
Keywords: goal and problems of cognitive modeling, information technology; cognitive modeling; two-level model; industrial-investment self-development; medium-sized and single-industry cities system; cognitive modeling structure.

RESUMEN:

El artículo trata de los problemas de modelación cognitiva del desarrollo de la inversión industrial de las ciudades de tamaño mediano y de una sola industria, que permiten realizar un análisis gradual de la estructura de modelado cognitivo, incluyendo una idea inicial sobre el modelo sistema económico; formación de esquemas conceptuales y estructura cognitiva de modelado en su base; Análisis estructural del modelado cognitivo; modelado de desarrollo de sistemas; Análisis de escenarios; interpretación de los resultados; Análisis de resultados de modelado.
Palabras clave: objetivo y problemas del modelado cognitivo, tecnología de la información; modelado cognitivo; modelo de dos niveles; autodesarrollo de la inversión industrial; sistema de ciudades de tamaño mediano y de una sola industria; estructura de

	modelado cognitivo.

1. Introduction

Setting goals of cognitive modeling of industrial and investment development of single-industry towns and medium-sized cities is determined by the strategic goal, that is the socio-economic development and ecological and food security of the local population. It is worth noting that the mere possession of the information resource is not enough to make a strategic informed decision. It is now important to organize information resource in order to acquire knowledge about the theory, methodology, practice and experience of the development of the research object.

In the twenty-first century, mankind has been trying to solve problems on the basis of cognitive technologies. Cognitive technologies are informative technologies that characterize mental action – information technologies. It should be noted that in a significant increase in information resource (Note 1) which includes contradictions and ambiguities, the main problem is to reduce the time for taking any decision, where the traditional approach is inefficient, and as a consequence is ineffective.

Problem formulation of cognitive modeling of industrial investment development of medium-sized and single-industry cities makes it possible to analyze the specific processes which will be realized with information technologies (Melikhova, 2013). New technology creation of a two-level model is proposed for modeling the development of the examined types of the cities; the cognitive model is realized at the lower level of the model amplifying common predictive development trends of the cities taking into account reallocation of investment flows (Rogachev, 2013; Rogachev, & Melikhova, 2014; Matveenko, & Shokhnekh, 2014.; Medvedeva *et al.*, 2015).

2. Methods

The fundamental methods are the methodological foundation of examination: systematic, typological; structural-functional, statistical analysis and economic-mathematical modeling (Skiter *et al.*, 2014; Skiter *et al.*, 2015). As a special method, the formation of the cognitive model was proved at the lower level for proving of combination and association factors which should be considered when forming the higher level of the economic-mathematical model. Experimental studies are conducted on the materials of the typical medium-sized city (Volzhsky) and the single-industry city (Mikhailovka) of the Volgograd Region. The analytical treatment of the experimental data is carried out with the use of the correlation and regression method using “Statiatica 10” software purchased by means of the grant (Rogachev, 2013; Rogachev, & Melihova, 2014).

3. The results of the study

In the new millennium, it is cognitive technologies that are the leaders by semi-structured systems effect; these systems are characterized by versatility of processes occurring in them, the lack of full, sufficient and quantitative information characterizing their dynamics and unclear situation. We apply in practice the automation of such mental actions as: intuition, experience, associativity in thinking, foresight.

In single-industry cities which have a low level of socio-economic development it is important to enhance the knowledge about the object, its structural elements for prediction the alternative direction of development.

Setting goals of cognitive modeling of industrial and investment development of single-industry towns and medium-sized cities should cover the areas of society such as the development and local support of the specialized business using the experience of similar cities and including a comprehensive plan; a roadmap with instructions, potential performers, optimal direction of

motion based on local weather and seasonal conditions, as well as infrastructure and communication security.

Setting goals of cognitive modeling of industrial and investment development of single-industry towns and medium-sized cities includes the introduction of the vital activity of "technological recognition system" based on the formation of the unique, giant knowledge base of the object, its structure, strengths and weaknesses, on weather and environmental conditions, the availability of economic resources, the ethnic and religious component and the possible directions of development.

The local government bodies of the Russian cities can take forward looking scenarios for their calculations while developing the strategic plans. The parameters of the conservative scenario are more suitable for the cities with well-developed fuel and energy sector and material sector of the economy; the parameters of the innovation scenario are more suitable for the cities with a strong innovative potential (high technologies, science and education); the parameters of the stepped-up scenario are more suitable for the cities characterized by an intensification of all available factors of the economic growth (Table 1).

Table 1
Main scenarios of long-term development of Russia up to 2030.

Conservative	**Innovative**	**Stepped-Up**
Active modernization of the fuel and energy sector, and materials sector; the use of foreign technologies and knowledge	Strengthening of investment activity, creation of modern transport infrastructure, competitive high-tech productions, development of knowledge-driven economy	Intensification of all available factors of economic growth, improving the business climate, activation of national savings, the increase in public spending on social development, energy and transport infrastructures
The annual growth rate up to 2030:		
GDP at the level of 3-3.2%, investment in fixed assets – 4.7%.	GDP at the level of 4-4.2%, investment in fixed assets – 5.9%.	GDP at the level of 5-5.4%, investment in fixed assets – 8.2%.
Russia's share in the world GDP up to 2030:		
Will decrease to 3.6%	Will increase to 4.3%	Will increase to 5.3%

For satellite cities and megalopolises it is advisable to use the parameters of two scenarios: *innovative* and *stepped-up* ones, because there is a synergistic effect of productivity growth as a result of 2-hour accessibility of the cities:

- Greater availability of business to a distribution area and labour markets;

- Time limit for business travel which helps to reduce costs for business trips and negotiations with business partners;

- Increase of labour productivity by 2 times for small businesses (World Bank data);

- Positive effect for acceleration of interregional communications; for small and medium entrepreneurship – expansion of sales, supplier and labour markets by 30%, 20% and 15%, respectively; increase of innovation implementation by 40%.

The industrial production remains a determining factor in the development of the leading

countries; the share of industrial production accounts for about 20% of the world GDP and 14% of the jobs from total amount. Given that the industrial production needs a large amount of services, we can indirectly understand that it creates about 30% of the jobs. For example, in the US, 19 cents of every dollar of product price of industrial enterprises are related to the purchase of different services (consulting, transport, communication).

In Russia there are about 90 medium-sized cities with a population of over 15 million. Sixteen medium-sized cities with high industrial potential (volume of products produced by the industrial enterprises in the total volume of the output is more than 70% for the period of one year. The amount of product output per capita is more than 200 thousand rubles per year) were integrated into the group of the industrialized medium-sized cities (hereinafter – IMSC). The descriptive analysis of their socio-economic systems can predict certain regularities in their development. The processes of economic modernization develop with great acceleration in these cities (the average difference between the growth rates of the other group of medium-sized cities – two points); scientific and industrial complexes are updated and the new types of businesses ("assemblage point" of urban open space) and transport and logistics systems are formed; global standards of consumption that contribute to the development of SMEs are quickly implemented; the ever-growing needs of enterprises in innovation lead to changes in the higher education infrastructure; investment activity increase ensures the creation of high-paying jobs; improvement of living standards accelerates the pace of growth of luxury housing and formation of suburban municipalities that combine the conditions of urban and rural life; the need to increase the volume of city product stimulates the cooperation of business representatives with the authorities.

Indicators of the development of the group of the industrialized medium-sized cities are shown in Table 2.

Economic policy in these cities under sanctions of the leading states more and more tends to increase its own production of goods and services, as well as the size of the working class and the number of engineers and technical workers.

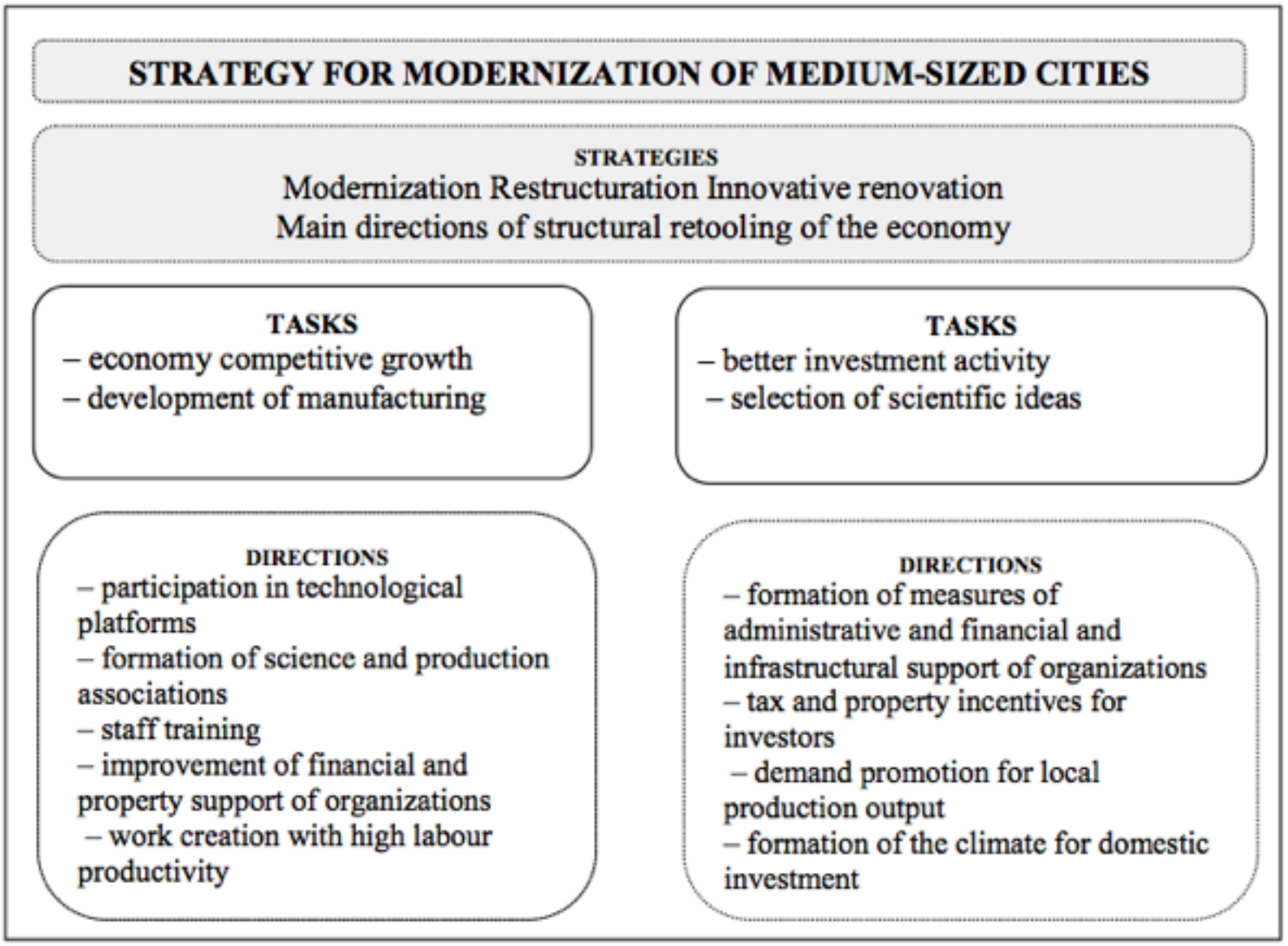
Table 2
Integral assessment of IMSC group (2014)

Mid-sized cities	**Labour productivity, ths. rub. / person.**	**Investment returns, rub.**	**Integral criterion**
Magnitogorsk	702.7	21.5	1.38
Nizhni Tagil	652.9	15.1	1.08
Volzhski	586.7	15.5	1.05
Cherepovets	1468.8	13.1	1.55
Surgut	1534.1	28.4	1.71
Sterlitamak	637.4	15.4	1.07
Komsomolsk-on-Amur	683.2	13.4	1.03
Taganrog	388.1	29.6	1.81
Nizhnevartovsk	1689.5	12.7	0.73

Bratsk	899.2	23.9	1.61
Nizhnekamsk	1091.0	11.9	1.75
Novorossiisk	521.1	10.4	0.94
Stary Oskol	981.9	12.2	1.18
Norilsk	104.,8	19.4	1.45
Dzerzhinsk	376.0	13.6	0.83
Orsk	607.1	7.1	0.71

The main directions of modernization of the industrial potential of the economy of medium-sized cities are shown in Figure 1.

Figure 1
The main directions of modernization of the industrial sector of the economy in the mid-industrialized city

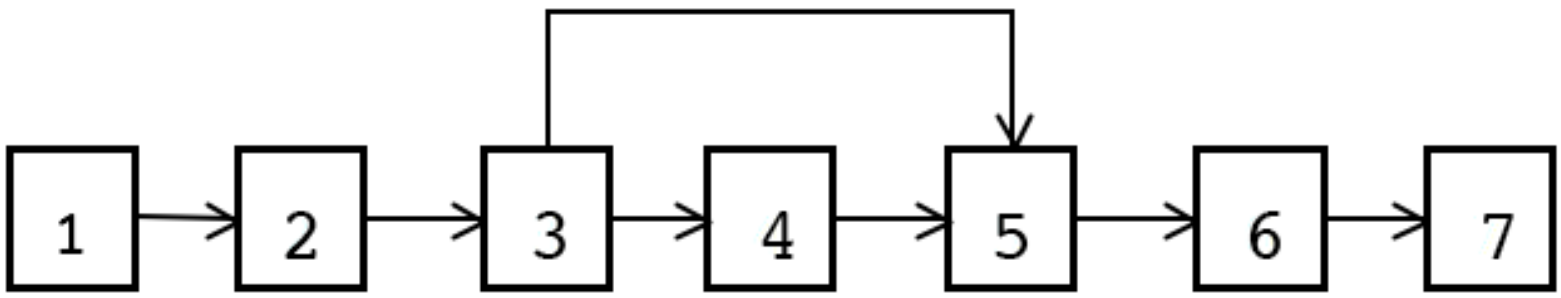


Optimization process of investments allocation in the context of rural settlements and medium-sized cities requires the use of economic and mathematical modeling (EMM) which allows taking into account the features of logistics processes of production and consumption. The analytical methods of dynamic modeling known in economics based on mathematical models in the form of differential equations are considered to involve major groups of factors and description of the associations between them, often linear ones (FCMapper – our Fuzzy Cognitive Mapping

Software Solution, n.d.; Rogachev, 2015). For medium-sized cities modeled in this study there can be an overwhelming ascendancy of some companies or their groups uncharacteristic for large cities. Therefore, it took the preliminary unclear cognitive identification and estimation of the impact of these dominant factors and their relationships with regard to the surrounding infrastructure. Such an approach to the modeling of the development dynamics of small cities and rural communities in the light of investment flows can significantly reduce the amount of numerical experiments when forming the adequate economic and mathematical model (Tokarev *et al.*, 2014; Shokhnekh, 2016).

The developed information technology (IT) and the formation of the cognitive model by the example of medium-sized city development include the following steps (Figure 2).

Figure 2
Structure of IT cognitive modeling and analysis of medium-sized city development



1 – initial idea about modeled economic system; 2 – formation of the conceptual scheme and structure of the cognitive model based on it; 3 – the structural analysis of the cognitive model; 4 – system development modeling; 5 – scenario analysis; 6 – interpretation of the results; 7 – the analysis of modeling results

The stages 1 and 2 of cognitive modeling are carried out by specialists, knowledge engineers; the stages 3, 5 and 7 – by experts-analysts; the stage 4 accepts the computer support using, for example, a specialized software called FCMapper (FCMapper – our Fuzzy Cognitive Mapping Software Solution, n.d.; Rogachev, 2015).

The well-founded group of enterprises (financial, fund-creating and consumer ones) was acting as the object for modeling. They provided the functioning of urban infrastructure in terms of their effect on its economy.

The model took into account labor mobility and investment that can freely move between companies. Production capacity of each group of enterprises was set in the form of production functions (Formula 1):

$$Xi = Fi(Ki, Li, Ii),\ i = 0, 1, 2, \quad \textbf{(1)}$$

where ***Xi, Ki, Li, Ii*** – output of products, basic production assets, number of employees in the *i*-th group of companies, investments in the *i*-th group of companies.

Additionally, the rate of change of investment flows was taken into account for clarifying their effect ***dKi/dt***.

The received structural scheme of the interaction of material and financial flows and labor resources in the economy of the city was realized by a cognitive map. The time ***t*** changes discretely in the cognitive model.

4. Results and discussion

The main disadvantages of the traditional cognitive map (limited application and impossibility of strictly numerical modeling of the system behavior) are eliminated in the different versions of fuzzy cognitive map (FCM) which is called the causal network – G (Formula 2):

$$G = (C, W)\ \textbf{(2)},$$

where C is a set of concepts, W is a set of links between the concepts $w(ci, cj) \in W \rightarrow [-1; 1]$.

The fuzzy cognitive map sets the numerical values of degrees of links causality showing how one concept affects the other. It is usually suggested to experts to use the following scale when generating maps: has strong influence (+1.0), has influence (0.5), has no effect (0.0), has negative effect (-0.5), and has significant negative effect (-1.0). In the case when the values of the weight function of causal links are extracted from the data obtained in the learning network the weight functions take the values from the range {-1; 1}.

5. Conclusion

The need for modeling of industrial and investment development is determined by the financial component; it will attract investors based on demonstration of the forward looking social and economic results of the investment project with the help of cognitive information technologies and taking into account lack of information determining the appropriate actions of leveling risks. Problem formulation of cognitive modeling of industrial investment development of medium-sized and single-industry cities make it possible to use the new technology of the two-level model, at the lower level of which the cognitive model is implemented amplifying the predictive development trends of the cities taking into account the reallocation of investment flows.

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Note 1

The studies show that nowadays the amount of information accumulated by mankind doubles every 4 years; however, the amount of information in the information resource will double approximately every 72 days until 2020.

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