Intelligent Information Technologies and Systems in the Systemic Research of Marketing Space

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Abstract: Spatial science, as an area of interdisciplinary scientific research, has become especially popular in the last decades. Nowadays spatial aspects are one of the very well-known objects of analysis of the different knowledge fields. The use of spatial systemic paradigm in the context of market relations in Russia presupposes complex research of how the subjects of marketing space interact with each other. This paper deals with the issues of Russian and international researches in the field of intelligent information systems applications for systemic marketing research and how it can be properly supported by contemporary information communication technologies. The class of intelligent information technologies (IIT) and systems, including neural network (NN), fuzzy logic (FL), multi-agent systems (MAS), belonging to the class of expert systems, continue to improve. The main goal of this paper is consideration of the issues of soft computing and agent based modeling implementation for spatiotemporal analysis, and the main domains or areas of their applying in the context of spatial economics. The objective of this research is characterization of qualitative and quantitative parameters that impact on equilibrium of operation and development of spatial marketing systems and formation of conditions for maximizing its effectiveness. It is empirical and theoretical research in equal measure. The study is based on literature review, analysis of large volumes of information, and findings of investigations in this field. The research problem is focused on the applying of modeling for analysis of spatial marketing systems. The original contribution of the work is describing the hybrid intelligent model, which contains all three elements - optimization, simulation and fuzzy inference system. Research methodology is methods and procedures of modeling. The paper also contains theoretical foundations and brief comparative analysis of different modeling methods and systems (including soft computing and agent based approach) and quantitative results obtained through the experimental model.

Keywords: Global economy, marketing, marketing space, spatial marketing system, intelligent information technologies and systems, hybrid intelligent model

1. Introduction

At the present time the use of the latest achievements in the field of Information Communication Technologies (ICT) in global economy and management, including contemporary intelligent information technologies (IIT) and systems of distributed artificial intelligence, is one of the factors in improving organizational performance and increasing competitiveness. Their successful integration into information structure of enterprise improves the quality of goods and services, enhances customer satisfaction, increases productivity, saves labor and materials costs, and etc. ICT can govern the ability of companies to generate the sustainable business models in global environment.

The class of intelligent information technologies and systems, containing neural networks (NN), fuzzy logic (FL), multi-agent systems (MAS), belonging to the class of expert systems, is continuing to improve. IIT and systems are based on information and communication resources which relate to the class of synergistic resources. Intelligent information technologies are complex, require further research and development.

The other point that's worth noticing is that attention of many scientists, including researchers in the field of spatial sciences, in particular, spatial economics, more and more focuses on the study of such significant elements in formation of spatial relationships, as information infrastructure and architecture of spatial information systems. Great importance, both in Russia and in the other countries, is given to the development of global, regional and national spatial data infrastructure. The most known initiatives in this field are the existing international programs: Infrastructure for Spatial Information in Europe, National Spatial Data Infrastructure, Global Spatial Data Infrastructure, and Global Monitoring for Environment and Security. What is

famous concerning Russia is that the general architecture has already created and the main components of the Russian segment of the information infrastructure and its integration into the world system have defined.

The major advantage of the spatial approach is the ability of multidimensional representation of spatially localized complex systems, in which the economic, ecological, social, geographical, political, and technological components interact. These components determine the functioning equilibrium and development of the region, as well as creating conditions to maximize region's contribution to the spatial systems development of higher level. The basis of the spatiotemporal concept to management is the principle of systemic approach and consideration of management system as a large complex system consisting of elements of different types and having heterogeneous relationships between them. Spatial system of management (including of spatial marketing systems) is treated as a complex system, a set of subsystems and their relations in many dimensions: social, industrial, territorial, etc.

The objective of this research is characterization of qualitative and quantitative parameters that impact on equilibrium of operation and development of spatial marketing systems and formation of conditions for maximizing its effectiveness. The decision of such multicriteria tasks involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. The research problem is focused on the applying of modeling for analysis of spatial marketing systems. In other words, the problem the author works with here is: How organizations can successfully use intelligent technologies and systems of modeling for business analysis under consideration of spatial approach. The rest of this paper is structured as follows: Theoretical background; Brief literature review and methodology; Systemic researches of marketing space; Model for evaluation impact of market factor, Conclusion, and References.

2. Theoretical background

The main advantage of the scientific research area, which is based on the spatial approach, is its interdisciplinarity and ability to take advantages of systemic approach and synergy effect in the study of issues related to the spatial organization of economy and management systems, including marketing systems. Problems of economic space have attracted the attention of ancient philosophers (Aristotle, Plato), founders of social utopias (T. Moore, T. Campanella, C. Fourier, R. Owen). These problems were reflected in the structure of created economic theories in XVII - XVIII centuries. Theories of regional product specialization and inter-regional trade for the first time were proposed by international affairs experts, not by experts in the field of regions development. First of all, it is necessary to mention the famous classics of English political economy - A. Smith and D. Ricardo, then the Swedish economists - E. Heckscher and B. Ohlin. Fundamentals of spatial economy were founded within the German scientific school (J. Thunen, A. Weber, A. Losch, W. Christaller, and W. Launhardt) and American scientific school (W. Isard). Representatives of these scientific communities had created the theoretical basis of modeling of spatial-temporal organization of the economy. They grounded the regularities of differentiation of spaces and transforming its individual components in a competitive economy. But the definition and conceptual framework of the spatial sciences are still in the stage of discussion and debate.

Several scientific schools of spatial economics were founded in Russia: in St. Petersburg and Moscow, Far Eastern school, Siberian school, and the Ural school. The Economic Research Institute of the Russian Academy of Sciences (RAS), with the support of the Scientific Council for Regional Development at the RAS Presidium, has been publishing the academic journal “Spatial Economics” since 2005. RAS’s research program “Fundamental Problems of Spatial Development of the Russian Federation: an Interdisciplinary Synthesis” was started in 2009.

In accordance with the basic hypothesis of the program, spatial science is defined as an interdisciplinary scientific direction, and objects of research are forms and processes of a modern society, which are space-dependent (Granberg, 2009). Three statements are offered as a conceptual basis. They related to the spatial, regional and international aspects. The first statement affirms that every category of economic activity or vital activity has its own space (spatial aspect). All kinds of spaces have a number of common characteristics: the extension in different directions, position relative each other in space, nodes (centres), networks, etc. The second statement concerns the regional aspect and supposes that the spatial science is considered as more broad research area, rather than “regional science”. The third statement is devoted to the international aspect and the program’s author had formulated it as follows: the strategic objective of the program is to provide

theoretical and methodological foundations of forming harmonious and competitive space of Russian Federation integrated into the world space (Granberg, 2009). Speaking about the development of methodological and methodical tools of interdisciplinary research in the field of spatial sciences, we should also mention such Russian fundamental studies as the monograph of Minakir P.A. (Minakir, 2006) and the textbook written by Granberg A.G. (Granberg, 2000).

The concept and theory of the "economic space" was formed in compliance with geographic, geopolitical, and regional concepts. And now the economic space is considered in the framework of concepts of globalization, industrial spatial clusters, "cumulative causation", high information technologies and network. Analysis of points of view on the economic space can be divided into four approaches to the study of this category:

- Territorial,
- Resources,
- Information, and
- Process.

The territorial approach has long dominated over the other approaches. The essence of this approach is based on economic space as a saturated territory having a plurality objects and the relationships between them. Resource-based approach determines the economic space as an environment for decision making about use of resources. The essence of the information approach is that economic space is considered as the information component of the economic process. Information approach adequately reflects the role and importance of information exchange between business entities. Process-based approach gives reason to determine the economic space as a relationship between economic processes of business entities and aggregate economic process with the purpose of formation of the possible outcomes of economic activity. Adding the marketing function to the structure of the functions of economic space is dictated by the need to replicate the economic space in time under the influence of scientific and technological progress, innovation, transformations in the environment due to the constant changes in requirements and fluctuations of supply and demand (Bagiev, *et al.*, 2012).

3. Brief literature review and methodology

The methodology of this research is methods and procedures of modeling. Nowadays, the combination of different approaches, styles, and paradigms for building of the most appropriate and efficient single hybrid model is one of the effective methods for use of intellectual tools for solving management problems. One of the examples of this approach is the development of model for the study of such important characteristics of management systems as sustainability and adaptability of their information architecture in the context of spatial economics.

The use of modern modelling methods and technologies are now essential components for developing management decision process that will enable companies to succeed in a rapidly changing environment. It is noteworthy that simulation is now considered an essential feature of decision making in companies that actively employ modern information technologies. The increasing demand for optimization of architecture of spatial marketing systems has caused leading modelers to consider intellectual information technologies and computer modelling in order to obtain deeper insights into complex and interdependent processes.

Modern modelling tools should facilitate mutual understanding at different organizational levels when making strategic management decisions thus bridging the gaps between a strategic vision and its implementation. The major approaches (or methods) in simulation for business are: System Dynamics (SD), Discrete Event (DE) and Agent Based (AB). While SD and DE are traditional approaches, AB is relatively new. Multi-agent systems (MAS) as a class have developed rapidly over the last decade. Compared to SD or DE models, AB models do not allow the definition of global system behaviour (dynamics); instead, the modeler defines behaviour at individual level, and global behaviour emerges as a result of the actions of multiple actors, each following its own behaviour rules, living together in some environment and communicating with each other and with the environment (Borshchev, Filipov, 2004; Karpov, 2005; Serova, 2013).

Agent technologies offer various types of agents, model of their behaviour and characteristics, through a range of architectures and components libraries. The notion "Agent" has developed from the well-known concept of

"object" which is an abstraction from a collection of real-world items with the same qualities and behavioural rules.

Serova (2013) argues that Multi-agent systems - as systems of distributed artificial intelligence - herald an era of networked organizations that are supported by the interaction of intellectual robots. This facilitates the shift from powerful centralized systems to fully decentralized ones, with hierarchical structure being replaced by a networked organization. Rigid, bureaucratic "from top to bottom" management is displaced by negotiation, and planning with flexible arrangements. As a result, production volumes, profitability, competitiveness and mobility are growing. A significant advantage of the Multi-Agent System approach relates to the economic mechanisms of self-organization and evolution which become powerful efficiency drivers for development and success of an enterprise. The Multi-Agent approach allows the creation of new intellectual data analysis which can be open, flexible and adaptive, and deeply integrated with other systems.

This does not mean however that Agent Based modelling is a replacement for System Dynamics or Discrete Event modelling. There are many applications where SD or DE models can efficiently solve the problems. If the problem's requirements fit well with Discrete Event or System Dynamics modelling paradigms – using these traditional approaches is more appropriate. In cases where the system contains objects with timing, event ordering or other kinds of individual and autonomous behaviour, then applying Agent Based or mixed approaches is more efficient (Borshchev, Filipov, 2004; Karpov, 2005; Serova, 2013).

Soft computing (SC) is a set of computational methodologies that collectively provide a basis for understanding, designing, and development of intelligent systems for using in various fields of science, including management. In contrast to traditional modeling methods, the essence of soft computing is that it has aimed at adapting to the inaccuracies of the real world. The scientific traditions, as a rule, give preference to the quantitative, formal, and precise theories and concepts. However, nowadays, this tradition has been changed by appearance of new problems for which finding of exact solutions was impossible, but the approximate solution methods of SC were quite acceptable. The main components of soft computing concept are fuzzy logic (FL), neural networks (NN), evolutionary computation (EC), and probabilistic inference (PE). Each of the above four methodologies has its strengths and weaknesses. Although they have some common characteristics, however, they can be considered as complimenting each other, because part of the required attributes missing from one technology, but can appear in the other (Krichevsky and Serova, 2016). Table 1 shows the comparative analysis of possibilities of intelligent technologies on certain criteria for major components of Soft Computing. Graduations of fuzzy logic are used as estimates of criteria.

Table1: Comparison of intelligent systems (source: Krichevsky, 2015)

Evaluation Criteria	Neural Networks	Fuzzy Logic	Evolutionary Computation
Mathematical model	Slightly good	Bad	Bad
Learning ability	Bad	Good	Slightly good
Knowledge representation	Good	Bad	Slightly good
Expert knowledge	Good	Bad	Bad
Nonlinearity	Good	Good	Good
Capability of optimization	Bad	Slightly good	Good
Tolerance of uncertainty	Good	Good	Good
Operating time	Good	Slightly good	Slightly bad

It is noteworthy that Fuzzy Logic is now considered as essential feature of decision making in companies that actively employ modern information technologies. Applying the information and communication technologies, which are used in soft computing, allows achieving the quantitative results, which is very important for manager to make a decision. Fuzzy set was introduced by Lotfi A. Zadeh (Zadeh, 1994) as a means of representing data that was neither precise nor complete. There are two main characteristics of fuzzy systems that give better performance for specific applications: the first is that fuzzy systems are suitable for uncertain or approximate reasoning and the second is that fuzzy logic allows problem solving and decision making on the basis of incomplete or uncertain information. Fuzzy technologies as technologies of artificial intelligence are now having a significant influence on information systems design and analysis (Kecman, 2001; Krichevsky, 2005; McNelis, 2005).

4. Systemic Researches of Marketing Space

Systemic researches of marketing space suggest that the main result of the study of the marketing system is not only the conditions of its formation, but the effectiveness of the optimal functioning and development. Particular attention in the systemic marketing research should be given to the study of causal relationships of the marketing system behavior and to identifying structure and its properties, which will ensure the effective implementation of marketing activities. Bagiev, *at al*., (2014) and Bagiev and Serova, (2015) have shown that systemic marketing research structurally will consist in study of three main areas:

- Theoretical foundations;
- Improvement of the management system of marketing;
- Marketing policy.

The basis of the spatiotemporal concept to marketing is the principle of systemic approach and consideration of marketing system as a large complex system consisting of elements of different types and having heterogeneous relationships between them. Spatial system of marketing is treated as a complex system, a set of subsystems and their relations in many dimensions: social, industrial, territorial, etc. (Bagiev, Serova, 2015).

As the most important properties of a large marketing system should be consider the next:

- Sustainable functioning and development;
- Adaptability;
- Reliability;
- Integrity and autonomy of its subsystems;
- Multicriterion choice of decisions;
- Synergy;
- Replication.

Definition of qualitative parameters that impact on equilibrium of operation and development of spatial marketing system and formation of conditions for maximizing its effectiveness entails consideration of four main groups of factors: market, macroeconomic, industrial, and social and technological (Table 2). The decision of such multicriterion tasks involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. All of these types of systems are not mutually exclusive. Moreover, there are hybrid systems that contain all three elements - optimization, simulation and fuzzy inference system.

Table 2: The main groups of factors and indicators (source: Bagiev, Serova, 2015)

Factors	**Indicators**
Market	Market segments
	Needs and demands
	Market issues (forces)
	Switching cost
	Revenue attractiveness
Macroeconomic	Economic infrastructure
	Commodities and other resources
	Capital market
	Global market condition
Industry	Competitors
	New entrants
	Stakeholders
	Suppliers
	Substitute products and services
Society and technologies	Societal and cultural trends
	Socioeconomic trends
	Technology trends
	Regulatory trends

5. Fuzzy logic model for evaluation of market factor impact

Market factor is one of the main forces influencing on equilibrium and sustainability of operation and development of spatial marketing system and formation of conditions for maximizing its effectiveness. Sustainability of architecture of spatial marketing system is determined by the stability of its structure, state parameters, and the most important is the stability of the current processes of its functioning and development. Adaptability of spatial marketing system first of all means its flexibility and property of adjusting itself under varying changes. Adaptive architecture of marketing information system is flexible and rational, customizable architecture that allows organizations of any size to react promptly to market and information flow changes. Design of sustainable and adaptive information architecture of spatial marketing systems is possible based on the applying of such intelligence information technologies as neural networks and fuzzy logic.

The Fuzzy Logic control model can be described as a next sequence:

- Problem input;
- Linguistic variable described by Fuzzy Set;
- If…then rules;
- Rules evaluation;
- Aggregation: Fuzzy output;
- Defuzzification;
- Decision.

The model for evaluation of market factor impact was created with the help of the fuzzy inference system (FIS) for four input variables and one output parameter. This FIS is destined for the assessment of the IS sustainability. The input parameters are market segments (X1); market needs (X2), market issues or forces (X3), and revenue attractiveness and switching costs (X4). Four selected attributes are included as input data to FIS. The output parameter determines the IS sustainability (Y).The control objective is to find the output value for a particular set of input variables. All calculations were performed in MATLAB v. 7.01 (Serova and Krichevsky, 2015). The number of the rules is the product of the number of terms in each input linguistic variable: 2*3*2*3=36. After the forming the base of rules the system of FL control gives the value of sustainability as conditional units. The results of experiment: the value of quality equal 80 points for given set of input variables: $X1 = 9,1$; $X2 = 8,8$; $X3 = 9,4$; $X4 = 9,2$.

6. Conclusion

At the present time the use of the latest achievements in the field of Information Communication Technologies (ICT) in global economy and management, including contemporary intelligent information technologies (IIT) and systems of distributed artificial intelligence, is one of the factors in improving organizational performance and increasing competitiveness. ICT can govern the ability of companies to generate the sustainable business models in global environment.

Interdisciplinarity of spatial marketing researches consists not only in expanding the subject of research, but in the synthesis of notions, concepts and methodologies of the social, humanitarian, sociological and engineering sciences, modelling and prediction of interaction and mutual influence of different kinds spaces, a generalization of the theoretical results and creating of the interdisciplinary databases.

Theoretical and empirical researches prove that spatiotemporal analysis of data can be performed through applying of contemporary intelligent information technologies and systems. System researches of marketing space, the use of spatial approach and multidimensional representation of spatially localized complex marketing systems may be based on the analysis of four main groups of factors: market; macroeconomic; industrial; social and technological. The decision of such multicriterion problems involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. Determination of the parameters that impact on the sustained development and operation of the spatial marketing system and creation of conditions for maximizing of its effectiveness is possible by using hybrid intelligent models.

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