Evaluation of Data and Simulation Modeling in the Implementation of the Smart City Concept for the Economies of Municipalities

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Abstract. The relevance of the research topic lies in the lack of tools to assess the level of the economy of the municipality from the perspective of the Smart City concept. The purpose of the study is to use tools to implement the Smart City concept in the economy of the municipality. The purpose is achieved by changing the evaluation criteria and applying the simulation model. The results of writing a scientific article are to consideration of the features of the Smart City concept, to determination of indicators for assessing the Smart City concept for the economy of the municipal formation, to the formation of a simulation model of the economy of the municipal formation in accordance with the Smart City concept. Research tools include the characterization method, the theoretical representation method, the data grouping method, the estimation method, the statistical method, the simulation method, the Bass diffusion method, the graphical method. Subsequently, the scientific article can be supplemented with an analysis of the Smart City concept for the economy of cities in the Central Federal District.

Keywords: the municipal economy, the Smart City concept, the change management, the imitation, the risk, digitalization.

Introduction

Changing conditions and the process of economic management led to the establishment of new principles for the functioning of the municipality. The concept of the Smart City has changed under the influence of the formation of the innovative direction of the territory, the technologicalization of the urban environment, the introduction of elements of the digital economy paradigm. The Smart City status is not assigned to all municipalities in the Smart City concept. Let's consider this statement in accordance with the highlighted aspects.

Firstly, the high debt dependence and budget deficit of municipalities doesn't allow the active introduction of the Smart City concept [14]. This condition is associated with building the innovative potential of the municipality. The Smart City concept creates a technologically active urban environment. The Smart City concept is based on the creation of an online platform [2]. The Smart City concept introduces information and communication standards to improve the life of the population [9]. The Smart City concept requires the development of a regulatory and legal framework

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[23]. For the municipality, statistical studies are carried out according to the given estimated parameters of Smart-elements [6]. These postulates can be realized through the possibilities of municipal budgets [15].

Secondly, “the overload” of the indicators of the statistical base doesn’t allow assessing the level of the economy of the municipality on the basis of the Smart City concept for [5]. This problem is related to two factors. On the one hand, the Smart City concept indicators are assessed on the basis of eight criteria. Smart City criteria include 15 or more statistical indicators [19]. On the other hand, statistical information is lacking in some areas of the Smart City concept. This factor doesn’t allow to form the final result of the development of the municipality [11]. For example, official statistics don’t provide data on the indicators “the level of citizens’ involvement in city management” [3]. Statistical studies include the indicator "“the level of activity of Internet users” [21], the indicator “the level of civil initiatives on local issues” [10]. The existing methodologies for assessing the Smart City concept are conditional.

Thirdly, the models for the implementation of the Smart City concept aren’t adapted to the Russian conditions for the development of the economy of municipalities [13]. This drawback is based on the lack of elaboration of the regulatory and legal framework and the Smart City design tool for the economy of municipal entities of the Russian Federation. The problem that has arisen is based on the introduction of digital technologies into the economy of the municipal formation [8]. The Smart City concept isn’t strategic for the development of the economy of municipalities. The Smart City concept is an element of the urban environment [18].

The selected aspects formulated the relevance of the research topic. To adapt the Smart City concept to the economic conditions of the municipality it’s necessary to simplify the existing paradigm. On the one hand, the methodology for assessing the Smart City concept is formed for the economy of the municipality. On the other hand, the directions of economic development of the municipality have been adjusted through the Smart City concept.

The purpose of the study is to use tools to implement the Smart City concept in the economy of the municipality. The purpose is achieved by changing the eval-uation criteria and applying the simulation model. The objectives of the scientific article include:

– to consideration of the features of the Smart City concept;
– to determination of indicators for assessing the Smart City concept for the economy of the municipal formation;
– to the formation of a simulation model of the economy of the municipal formation in accordance with the Smart City concept.

Literature Review

The Smart City concept for the economy of the territory is considered a tool, a means of modernization and a change management system. The scientific worldview within the Smart City tool focuses on the perception of the concept from the perspective of urban planning [32]. The basis of Smart City is the use of innovative means for the development of the urban environment [24]. The Smart City concept as an eco-

nomic tool presupposes: the intellectualization of public safety [35], the introduction of information city management [26], the formation of smart urban transport [30]. Another scientific position of the study of the Smart City concept is a means of modernizing the economy [34]. The Smart City concept implements technological modernization of the economy [22]. This modernization is based on improving the quality of life of the population through the introduction of new generation technologies [28]. However, this scientific view does not take into account the problem of the high cost of introducing technologies into the economy of municipal education [33]. The highlighted problem is associated with the limited budgetary funds of municipalities. On the other hand, the Smart City concept is considered as a system for managing changes in the economy of a municipal entity [27]. Change management is the process of tracking risks and emerging conditions of uncertainty in the economy of a municipal entity [31]. In our opinion, the Smart City concept is a change. This statement is due to the fact that the Smart City concept transforms the economy of the territory [25] and creates new relationships between agents of the local environment [29].

The Smart City concept is a system of conditions to ensure the modern quality of life of the city population through the introduction of innovative technologies [1]. The Smart City concept is based on innovative technologies. Innovative technologies are synonymous with smart technologies. Smart stands as the key criteria for the concept. The Smart City concept assumes the presence of directions of the urban environment. Areas of the urban environment include the smart management [12], the smart technology [17], the smart environment, the smart ecology, the smart infrastructure, the smart finance, the smart economy [7]. Features of the Smart City concept include the formation of an efficient urban infrastructure based on the introduction of artificial intelligence [4]. The Smart City concept introduces electronic processes for the participation of the population of the municipality in matters of economic development of the territory. Technologies are being introduced into the economy of the municipality [16]. On the basis of the Smart City concept, an assessment of the conditions for the development of the economy of the municipality is formed.

Methodology

The research apparatus is based on the implementation of the tasks set in a scientific article. To highlight the features of the Smart City concept are the method of characteristics, the method of theoretical representation. The formulation of indicators for assessing the Smart City concept for the economy of the municipality includes the method of grouping, the method of assessment, the statistical method. The formation of a simulation model of the functioning of the economy of a municipal entity within the framework of the Smart City concept are based on the method of simulation modeling, the method of diffusion according to Bass [20], and the graphical method.

Result

In the concept of Smart City is a problem of a large array of data for conducting a study of the economy of a municipality. Table 1 highlights the indicators of the Smart City concept for assessing the economy of the municipality.

Table 1. Evaluation indicators of the Smart City concept for the economy of the municipality.

The direction	The smart City concept assessment indicators	Evaluation indicators of the Smart City concept
The smart economy	The level of development of scientific and innovative activities, the level of development of the Internet booking system, the level of development of communication technologies.	The criterion for innovative diversity (I_{SC})
The smart management	The level of informatization of the city and the openness of the city government, the level of development of document circulation and strategic planning.	The criterion of information interaction of management agents (U_{SC})
The smart population	The level of accessibility of the labor market, the level of activity of Internet users, the level of use of electronic cards of students.	The criterion of intellectualization of the population (N_{SC})
The smart technology	The level of development of uninterrupted access networks, the level of development of telemetry, the level of development of free wireless access in transport.	The criterion digital support area (T_{SC})
The smart environment	The level of elimination of landfills, the level of monitoring of environmental safety.	The criterion of ecological safety (E_{SC})
The smart infrastructure	The level of development of car sharing, the level of development of public transport, the level of availability of a network of filling stations for electric vehicles, the level of development of information systems in urban planning.	The criteria for online media (F_{SC})
The smart finance	The level of transparency of procurement activities, the level of investment in the city's economy	The criterion of financial security (S_{SC})

In the context of assessment indicators of the Smart City concept, shortcomings are formulated. The shortcomings of the Smart City concept don't allow a full-fledged study of the level of economic development of the municipality in accordance with the highlighted postulates. Firstly, there is no calculation of the final result and it's impossible to draw a conclusion about the development of the economy of the municipal education. Secondly, the directions include many indicators for assessing the development of the economy of the municipality. Thirdly, statistical information on the indicators of the Smart City concept isn't freely available. The system of indicators of the Smart City concept isn't adapted to the statistical reports of the statistical services of the Russian Federation. The highlighted circumstances formulated the importance of forming the Smart City concept. The indicators for assessing the Smart City concept for the economy of the municipality are presented in Table 1.

Indicators for evaluating the Smart City concept for a municipal education economy include:

1. The criterion for innovative diversity (I_{SC}):

$$I_{SC} = \frac{P \times p_n}{C_e + C_i} - \frac{G}{I_n}, \quad (1)$$

where I_{SC} is the criterion for innovative diversity, P is the volume of shipped innovative products, goods and services (million rubles), p_n is the scientific and innovative potential of the municipality, C_e is costs of re-equipping the economy towards technological equipment (million rubles), C_i is costs of introducing information systems into the economy of the municipality (million rubles), G is the amount of grants received by scientific and educational organizations of the municipality in the current year (million rubles), I_n is the total cost of intellectual property products registered on the territory of the municipality (million rubles).

2. The criterion of information interaction of management agents (U_{SC}):

$$U_{SC} = \left(\frac{I_k}{I_{k-1}} \right) \times u_i - \left(\frac{I_u}{I_{u-1}} \right) \times u_o, \quad (2)$$

where U_{SC} is the criterion of information interaction of management agents, I_k is the number of citizens' initiatives registered within the framework of appeals to local governments in the current year (conventional unit), I_{k-1} is the number of citizens' initiatives registered in the framework of appeals to local governments in the previous year (conventional unit), u_i is the level of development of information systems of the administration of the municipality, I_u is the number of satisfied applications of citizens of the municipality, out of the number registered in the current year (conventional unit), I_{u-1} is the number of satisfied applications of citizens of the municipality, from the number registered in the previous year (conventional unit), u_o is the level of information transparency of the authorities of the municipality.

3. The criterion of intellectualization of the population (N_{SC}):

$$N_{SC} = \left(\frac{K_i}{K_b} \right) \times u_d - \left(\frac{K_n}{K_a} \right) \times u_a, \quad (3)$$

where N_{SC} is the criterion of intellectualization of the population, K_i is the number of jobs in the innovation sector of the economy of the municipality (conventional unit), K_b is the number of unemployed in the municipality (people), u_d is the level of accessibility of labor market information, K_n is the number of people working in the scientific and educational field (people), K_a is the number of economically active population of the municipality (people), u_a is the level of activity of Internet users of the municipality.

4. The criterion digital support area (T_{SC}):

$$T_{SC} = \left(Z_u \times Z_g \right) - \left(k_i \times i_e \right), \quad (4)$$

where T_{SC} is the criterion digital support area, z_u is the level of use of digital technologies in the daily life of the population of the municipality, z_g is the level of digital literacy of the population of the municipality, k_i is the coefficient of infrastructural accessibility of digital technologies in the territory of the municipality, i_e is the indicator of the effectiveness of using digital technologies for the economy of the municipality.

5. The criterion of ecological safety (E_{SC}):

$$E_{SC} = \left(p_e \times k_p\right) - \left(p_n \times k_v\right), \quad (5)$$

where E_{SC} is the criterion of ecological safety, p_e is the indicator of increasing the rate of environmental pollution of the territory, k_p is the coefficient of economic peril, p_n is the indicator of excess of standards for the level of waste, k_v is coefficient of harmful environmental impact, rendered by the enterprises of the municipality.

6. The criteria for online media (F_{SC}):

$$F_{SC} = S_o - S_n, \quad (6)$$

where F_{SC} is the criteria for online media, S_o is the amount of transactions made online (within the framework of infrastructure and transport services) (million rubles), S_n is the amount of cash transactions (within the framework of infrastructure and transport services) (million rubles).

7. The criterion of financial security (S_{SC}):

$$S_{SC} = \frac{D+F}{R+M+K} - \frac{Z \times u_r}{B}, \quad (7)$$

where S_{SC} is the criterion of financial security, D is the indicator of budget revenues of the municipality (million rubles), F is the indicator of financial result from the activities of enterprises located on the territory of the municipality (million rubles), R is the indicator of budget expenditures of the municipal formation (million rubles), M is the indicator municipal debt (million rubles), K is the indicator of accounts payable of enterprises located on the territory of the municipality (million rubles), Z is the amount of funds saved in the framework of procurement activities (million rubles), B is the amount of non-cash transfers within the framework of social and economic services for the population (million rubles), u_r is level of development of the banking system of the territory.

The indicators reflect the specific direction of the Smart City concept for the economy of the municipality. The direction of smart economy is the criterion for innovative diversity, the direction of smart management is the criterion of information interaction of management agents, the direction of smart population is the criterion of intellectualization of the population, the direction of smart technology is the criterion digital support area, the direction of smart environment is the criterion of ecological safety, the direction of smart infrastructure is the criteria for online media, the direction of smart finance is the criterion of financial security. The evaluation of the criteria is based on a positive result or a negative result. A positive result indicates the

formation of a direction in the economy of the municipality in the context of the Smart City concept. The negative result indicates that the Smart City concept is not typical for the economy.

The final results of the criteria for the Smart City concept are presented on the example of the economy of the municipal entity of the city of Orel (Table 2).

Table 2. Evaluation indicators of the Smart City concept for the economy of the municipal education of the city of Orel

Год	I_{SC}	U_{SC}	N_{SC}	T_{SC}	E_{SC}	F_{SC}	S_{SC}
2017	-1,6	-1,42	-1,86	-0,18	-2,42	**1,32**	-0,9
2018	-0,84	-1,25	-1,58	-0,82	–3,24	**3,42**	–0,88
2019	– 0,15	–1,20	–1,42	–0,90	–4,01	**4,15**	–0,82

The direction of smart economy for the economy of Orel is typical in the period 2017–2019 years. The economy of Orel partially contained elements of the Smart City concept in 2017–2019 years. Forecasting the development of the economy of Orel wasn't carried out within the framework of the Smart City concept for the entire study period. We will form a simulation model of the functioning of the municipal economy within the framework of the Smart City concept and the existing changes. The AnyLogic software is the tool for simulation modeling. The method of imitation is the Bass diffusion. The basis of the simulation model is to obtain the Smart City model for studying the economy of the municipality of Orel in a long-term period. The simulation model should show whether the economy of Orel will develop within the Smart City concept in 2025 year.

The initial stage of the simulation model is to check the final result of the directions of the Smart City concept. The simulation model of the

Smart City concept based on the example of the city of Orel is formulated on the basis of storage devices. The drives reflect the main directions of the Smart City concept. The directions are identical to the drives. So, the Orel drive is the municipality of Orel. The Economy drive is direction of smart economy. The Management drive is the direction of smart management. The Population drive is the direction of smart population. The Technology drive is the direction of smart technology. The Ecology drive is the direction of smart environment. The Information drive is the direction of smart infrastructure. The Finance drive is the direction of smart finance. The direction criteria of the Smart City concept are represented by dynamic variables. Dynamic variables implement a predictive function due to the given parameters and cyclical tuning of the economy of the municipality. The designation of dynamic variables is based on a criterion value. For example, the criterion for innovative diversity identical I_{SC}. The simulation model parameters are value-based. The model values reflect the final result of the dynamic variables. For example, for the criterion of innovative diversity, the set of variables include P is the volume of shipped innovative products,

goods and services, p_n is the scientific and innovative potential of the municipality, c_e is costs of re-equipping the economy towards technological equipment, c_i is costs of introducing information systems into the economy of the municipality, G is the amount of grants received by scientific and educational organizations of the municipality in the current year, I_n is the total cost of intellectual property products registered on the territory of the municipality.

The next stage in the formation of the simulation model is the simulation assessment of indicators of the Smart City concept for the economy of Orel. For example, let's create the Economy drive with a given dynamic variable and parameters for 2019 year. The final result of the development indicator for the smart economy direction for the economy of Orel is 0.15 in 2019 year. This condition must also be met within the simulation model. The Economy drive with parameters and variable values of 2019 year (Fig. 1).

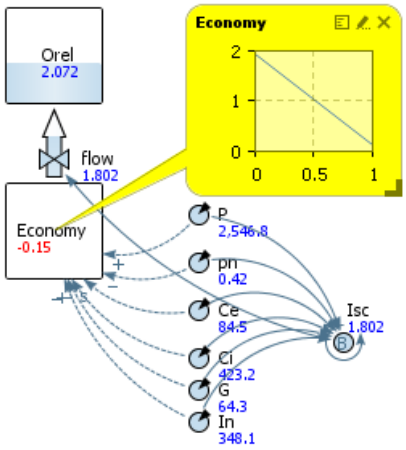

Fig. 1. Simulation of the smart economy direction of the Smart City concept on the example of the city of Orel

The resulting model in the direction of smart economy reflects the negative value of the criterion of innovative diversity. The value of the criterion of innovative diversity for the direction of smart economics of municipal education in Orel is -0.15. The formulated condition allows us to conclude about the accuracy of the generated simulation model of the smart economy direction for the city of Orel.

The purpose of using simulation modeling is the formation of the Smart City model for studying the economy of the municipality of Orel with a predictive function until 2025 year. This condition is necessary to determine the primary directions of the economy of the municipal education of the city of Orel. The priority areas will allow the Smart City concept to be implemented in the economy of the Orel municipality. To simulate the model, we will form the estimated accumulators with the given dynamic variables and parameters of the economy of the municipal formation of the city

of Orel. The forecasting lag is up to 2025 year. The limitations of the simulation model include the risk components from changes in the external environment and the transformation processes of legislative acts in the field of the digital economy. These restrictions are determined by the level of cyclicity of dynamic variables. The final model of the Smart City model for the study of the economy of the municipality of Orel is presented in Fig. 2.

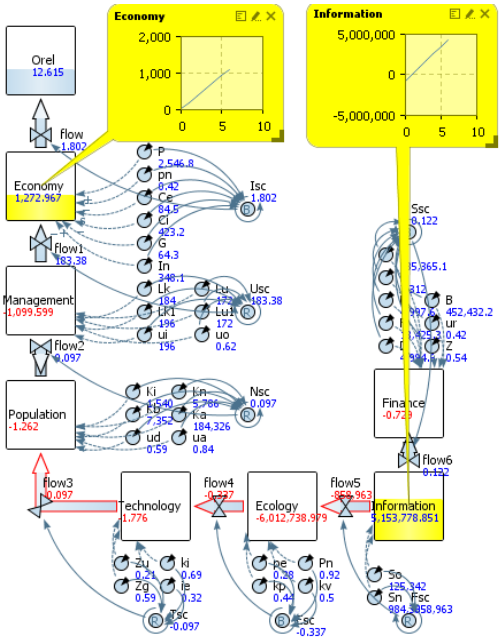

Fig. 2. The Smart City model for studying the economy of the municipality of Orel

The Smart City model for researching the economy of the municipality of Orel made it possible to establish a positive result of the smart economy direction and the smart infrastructure direction by 2025 year. Due to the development of these areas, the economy of the municipality of Orel can function on the basis of the Smart City model. An important feature of the model is the allocation of negative results in the directions of the economy of the municipal city of Orel. The negative dynamics of the drive indicates the problems in the functioning of this direction in the economy of the city of Orel. Negative dynamics is produced in the context of changes in indicators for 2019 year compared to the forecasted values of 2025 year. The directions of the economy of Orel with negative dynamics are the Technology drive and the Ecology drive. These directions require the formation of software products for the development of the territory of the city of Orel.

Discussion

Scientific research made it possible to identify several problems. Firstly, some economies of municipalities aren't adapted to the development conditions of the

Smart City concept. Secondly, there is no connection between the statistical indicators of the Smart City concept and the socio-economic reports of municipalities. Thirdly, simulation modeling isn't considered as a tool for forecasting the processes of introducing the Smart City concept into the economy of a municipal entity in the long term. These problems require discussion in further scientific research. Subsequently, the scientific article can be supplemented with an analysis of the Smart City concept for the economy of cities in the Central Federal District.

Conclusion

The conducted scientific research has led to the following conclusions.

1. The Smart City concept hasn't been tested for the current state of most municipal economies. The main disadvantages are to the lack of final results for evaluating the Smart City concept, to the overload of methods with the number of indicators when studying the states of the territories within the Smart City concept, to the impossibility of obtaining statistical data within the Smart City concept.

2. Based on the presented shortcomings, we form Smart City the concept for studying the economy of a municipal entity. This concept includes nine areas for assessing the economics of municipal education. These areas are assessed on the basis of criteria for the implementation of the Smart City concept: the criterion for innovative diversity, the criterion of information iteraction of management agents, the criterion of intellectualization of the population, the criterion digital support area, the criterion of ecological safety, the criteria for online media, the criterion of financial security.

3. Forecasting is manifested through the simulation of the Smart City concept for the economy of the municipality. For example, the values of indicators of the economy of the municipal formation of the city of Orel. The forecasting lag is 2025 year. As part of the study, it was established that the main directions of development of the city of Orel are the smart economy direction and the smart infrastructure direction by 2025 year. The attention of the executive authorities of the city of Orel requires the areas of the smart environment direction and the smart technologies direction. These directions show negative dynamics throughout the study period.

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