

Regional Policy of Using Digital Innovation to Build a City Digital Twin

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ABSTRACT

The integrated development of the modern urban environment, in accordance with the trend towards digitalization of socio-economic relations, is closely related to the concept of a digital twin. The use of this concept long before its final formation was reflected in the field of economic modeling, however, the current level of development of information technologies makes it possible to widely apply the achievements of science in practice, particularly in the field of urban management by creating digital twins of settlements. Despite the significant interest in the topic of digital twins of cities, the impact of the city management system, which is an essential and high-powered part of the city, on the functioning of such hardware and software complexes has been poorly studied. Due to the fact that the effective interaction with the digital twin of the city is impossible without the use of modern digital innovations while performing managerial and analytical activities, which are the conditions of forming the environment of digital twins, the authors analyzed the state policy in the field of forming so-called *smart cities* which widely use the last achievements of digitalization, including the technology of digital twins. The purpose of the analysis is to highlight factors influencing the formation of the innovative environment of implementation both of digital twins of cities in particular and high-tech system of city economy in general. Based on the study results, the authors revealed the significant effect of regional policy of constituent entities of the Russian Federation in the field of informatization of state authorities and local self-government on the development of *smart cities* in Russia, and developed a tool for determination of the intensity of the process of introducing innovative digital labor tools into the activities of management structures.

Keywords: *digital twin, digitalization, local self-government*

1. INTRODUCTION

In the 21st century, the rapid development of both information technologies in general and digital management tools in particular is becoming the factor on which the socio-economic development of mankind critically depends. The tasks of industrial relations facing the economy are so ambitious, due to the growth of modern science intensity and production complexity, that without the existing digital tools of production control, their solution cannot be obtained in the required time frame [1].

In accordance with the systematic approach, the efficiency of production as such is provided by a

combination of factors that, to varying degrees, affect both the final result of the production process and each other. Thus, the process of automating the management of production systems has historically been carried out along the path of integrating individual monitoring, planning and management tools into unified integrated systems [2].

This trend, combined with a significant rate of scientific and technological progress in the field of information technology, inevitably led to the emergence of the concept of a digital twin – a digital reflection of real processes and phenomena [3].

Despite the fact that this concept was introduced into scientific circulation only in 2002 by

M. Greaves, assistant director of the Center for Life Cycle Management and Innovation at the Florida Institute of Technology, the main components of the digital twin concept were used long before that [4]. So, since the second half of the 20th century, mathematical models have been widely used, which became especially popular after the advent of computers, and in the Soviet textile industry, complex models of the industry were created, which would now be called a digital twin.

At the same time, the relevance of this concept at the turn of the millennium should be associated with an increase in the availability of productive computing technology, which made it possible to move from labor-intensive modeling of individual critical systems to the possibility of cost-effective modeling of any objects related to human life, which is directly related to the broader concept of Industry 4.0 [5].

Having penetrated into the sphere of public administration, the concept of the *digital twin* led to the emergence of the concept of the digital twin of a city, which is an integral part of the concept of a *smart city* [6].

At the same time, despite a number of publications on the topic of the *digital twin of the city*, as well as significant interest in this concept on the part of both the Government of the Russian Federation and individual constituent entities, the scientific study of the issue affects, first of all, the very mechanisms of modeling the life of settlements and various opportunities that open up with this, leaving outside the aspects of interaction with the digital twin of the control system represented by state authorities and local self-government.

Based on a number of previously conducted works related to research on the implementation of innovative digital labor tools in public administration, the team of authors put forward a hypothesis that the aspects of the implementation of the digital infrastructure critically necessary for the implementation of the digital twin of a settlement as a whole, and the management subsystem of a digital city in particular, significantly correlate with the regional policy in the field of implementation of innovative digital tools in public municipal administration and lend themselves to formatted calculation.

2. MATERIALS AND METHODS

In order to provide an integrated approach to the study of the digital twin of the control subsystem of

digital modeling of the city, an analysis of scientific publications associated with the use of digital twin technology in state and municipal administration was carried out.

A special role in the study was paid to the analysis of the regulatory legal documents of the Russian Federation and its constituent entities. The economic analysis of planning and reporting documentation for the implementation of state programs of the constituent entities of the Russian Federation was widely used.

In the present study, such a general scientific method as observation was widely used. Methods of statistical, regulatory and economic analysis were also used.

3. RESULTS

In the context of the beginning of the introduction of such a phenomenon as a digital twin of a city in the everyday activities of state authorities and local self-government bodies, the analysis of the level of implementation of innovative digital technologies throughout the country is of particular interest [7].

This procedure is possible because the Ministry of Construction, Housing and Utilities of the Russian Federation (hereinafter – the Ministry of Construction of the Russian Federation) collects statistics on the implementation of mechanisms of digital management within the Program ‘Smart City’. On the basis of this statistics, IQ index of cities is calculated taking into account the complex of 47 indicators associated with the most of life aspects of a settlement. The calculation of these indicators is based on the methodology approved by the Order of the Ministry of Construction of the Russian Federation dated December 31, 2019 No. 924 / PR.

Each of the basic indicators received its own calculation formula, which allows both to take into account the features of the digital transformation processes reflected by the indicator, and to ensure the possibility of comparing various indicators with each other. Most indicators are determined by the following formula (1):

$$I = \frac{Nd}{Nc}, \quad (1)$$

where I – a calculated indicator; Nd – a quantitative indicator of digitalization of a certain area of city life; Nc – an indicator associated with Nd, characterizing the general state of this sphere in the city.

The undoubted advantage of this technique is the reduction in computational costs required to calculate indicators. So, the calculation of 47 indicators out of about 130 characteristics for 203 cities that participated in the calculation of the index in 2019 is available on the average performance of an office PC using a spreadsheet processor. Thus, the organizational aspects of collecting initial data are of primary importance for the correctness of the index calculation according to the existing method.

The disadvantage that follows from the advantages is the low level of detail of the indicators, which divides some of them from the real display of digitalization processes. Thus, the indicator *the number of CCTV cameras in relation to the area of urban land* will have different meanings for the city of Volgograd with a population density of 1169.21 people for 1 sq. km and the city of Rostov-on-Don with the same indicator of 3264.57 people for 1 sq. km, though both cities are included in the single *Largest cities* category. Similarly, the indicator of the availability of an automated rental system for cities with different climatic conditions has a different relevance, and the calculation of the indicator of population involvement in the work of a digital platform for solving urban development issues provides less relevant indicators without taking into account the demographic proportions of the city's population.

Thus, it should be noted that there is a significant potential for modernizing the methodology for calculating indicators. At the same time, based on the novelty of the task at hand, it should be borne in mind that to modernize the methodology, empirical experience is needed, which, despite some imperfections in the calculation of the index, allows collecting statistics in this area. Based on the above, the determination of the optimal universal methods for calculating indicators of the effectiveness of the implementation of innovative digital mechanisms in each of the areas is a field of scientific activity with significant potential for the application of the results.

Provided that the above methodology is adopted as the most correct in the current conditions, it becomes relevant to analyze the *urban governance* section of the index, which is of particular importance in the context of this study. The values of the indicators in this section are shown in *Figure 1*.

The indicators shown in *Figure 1* reflect the positive dynamics of digitalization of the urban management subsystem: relative to 2018, the growth of the average indicator for the group of indicators

was 22.29%. At the same time, it is necessary to take into account the qualitative components of these indicators.

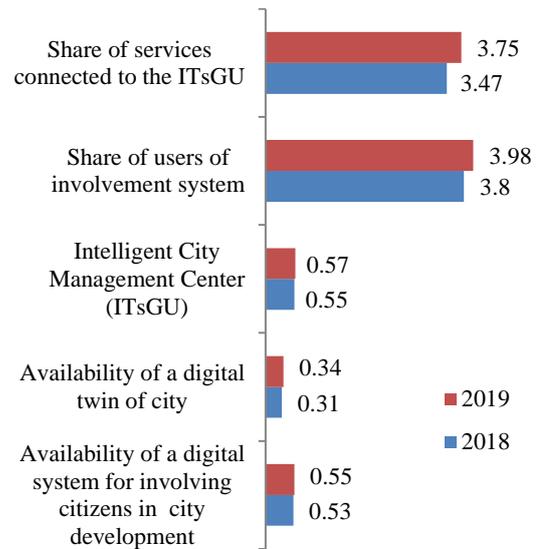


Figure 1. Indicators of *urban governance* section of IQ index of cities for 2018-2019

Source: Compiled by the authors based on [8]

Thus, two of the five indicators are associated with the creation and development of a digital platform for interaction with city residents. These indicators are of direct importance for the development of the institution of local self-government, thereby affecting the control subsystem, however, the basic indicators, that characterize the composition of the digital platform when calculating the index, reflect only the need to digitize the processes of receiving applications from citizens and public initiatives, as well as significant processes related to urban governance are reflected in electronic form (in cartographic mode) [9].

At the same time, the interconnection with the control subsystem is reflected only in the basic indicator of synchronization of the platform with the Intelligent City Management Center (ITsGU), which, being the electronic dispatching center, monitors the city infrastructure in accordance with the calculation methodology. Nevertheless, despite the fact that the monitoring link is brought into autonomy status in accordance with the methodology, the basic indicators associated with the ITsGU involve the labor of employees of the control subsystem. At the same time, the above indicators are aimed at ensuring monitoring of the control object and the formation of a stable feedback. The functioning of that part of the control subject that remains outside the ITsGU is not taken into account by the index.

In the context of this study, of particular importance is the indicator of *availability of a digital twin of city*. Despite the fact that most of the basic indicators are devoted to the work of cartographic subsystems, it is supposed to take into account possibilities for modeling management decisions and synchronizing the work of city services. The efficiency of using this functional of a digital twin of the city is directly related to the level of digitalization of the control subsystem [10]. So, management decisions often require coordinated actions of employees of a number of departments.

Nevertheless, even taking into account the above-mentioned features of calculating the category of *urban governance*, the indicators of cities remain rather low. So, even taking into account the significant growth, which amounted to more than 20% for the period from 2018 to 2019, the digitalization of urban governance is one of the five areas in which the least achievements are observed in the surveyed cities. The ratio of categories in the IQ index of cities for 2019 is shown in *Figure 2*.

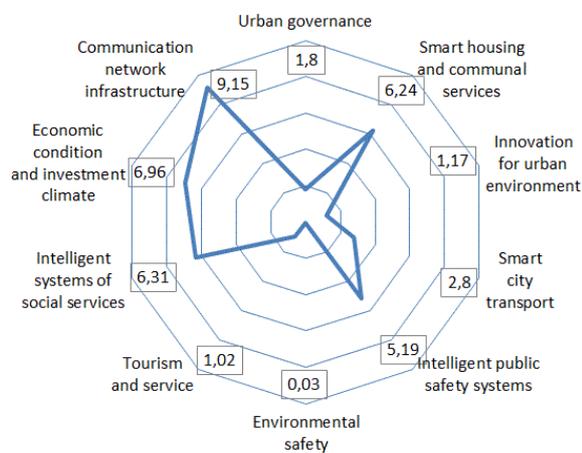


Figure 2. Ratio of categories of IQ index of cities for 2019

Source: Compiled by the authors based on [8]

As follows from the data presented in *Figure 2*, the category of *urban governance* prevails only over the categories related to ecology, tourism and urban innovation. Low values of these categories are associated with the specifics of calculating indicators. So, the ecology indicator is calculated based on the following conditions:

- availability of sensors for monitoring environmental indicators, the installation of which has different practical significance for cities with developed industry and those in which there is practically none;

- the development of the tourism sector in many cities of the Russian Federation is not at a high enough level for digitalization in this area to be economically feasible in the short term;
- urban innovation can be costly enough for small towns to afford.

Thus, the low indicators of the *urban governance* category, the basic indicators of which are achieved through, first of all, organizational measures and the development of the internal information infrastructure, lead to the question of the effectiveness of internal digitalization of the urban management subsystem.

When considering the results of the index for 2019, it is impossible not to note the leadership of the Moscow Region in all assessment groups in terms of population (with the exception of the *largest cities* group, due to the absence of such). Thus, the quantitative ratio of the cities of the Moscow Region and other regions by the eight leaders of the assessment groups is shown in *Figure 3*.



Figure 3. Ratio of categories of IQ index of cities for 2019

Source: Compiled by the authors based on [8]

Based on the data presented in *Figure 3*, even taking into account the factor of the quantitative ratio of cities in the constituent entities of the Russian Federation, one cannot fail to note the high development of the elements necessary for building the infrastructure of the digital twin of the city in the settlements of the Moscow Region. In this regard, it seems necessary to clarify the reasons for the high achievements of this region.

Based on the analysis of the digitalization process of the region, it was revealed that by 2019, in the Moscow Region at the regional level, state

and local authorities had an assured access to digital tools necessary to achieve the rating indicators.

So, in each of the municipalities, a video surveillance system ‘Safe Region’ was introduced. At the regional level, a platform for interaction with the population “Dobrodel” was created, involving each settlement of the region. Local authorities were provided with access to cartographic and other systems. In accordance with the state program of the Moscow Region “Digital Public Administration”, it is planned to unify the information infrastructure of the cities of the region, which in fact implies the provision of *smart* innovative management tools to all cities of the Moscow Region.

This direction can be traced in the passport of the regional project “Smart Cities of the Moscow Region”, in which, on the basis of the integrated use of existing information systems, a plan was formed to achieve high indicators of the IQ index of cities.

Another step on the way to creating conditions for mass implementation in 2019 in the cities of the Moscow Region of the digital twin technology was the creation of the Regional Management Center (TsUR) of the Moscow Region and the creation of similar structures in the municipalities of the region. This structure, which combines the functions of the ITsGU and the processing of applications, is largely associated with the achievement of the above-mentioned high dynamics of indicators in the *urban governance* category of the index in relation to 2018.

For comparison, in the Leningrad Region, the most comparable in terms of socio-economic conditions, the development of the *smart city* infrastructure is purposefully carried out only in two cities, and the cost of the development of state information systems amounted to 91 million rubles. For comparison, the cost of similar processes in the Moscow Region amounted to 842 million rubles. Based on the data on the population size and regional budget costs, it is possible to calculate the index of the relative costs of digitalization using the formula (2):

$$Iidg = \frac{Edg / Np}{Bep} * 1000, \quad (2)$$

where Iidg – the index of relative costs for the creation and development of digital instruments of public administration; Bep – per capita budget expenditures; Np – population size; Edg – expenses for the development and support of information systems (excluding the cost of providing services in electronic form).

This indicator is able to reflect the role of management digitalization in the activities of the regional government, allowing us to compare the activities of regions with different socio-economic conditions. So, when comparing the Leningrad and Moscow Regions, this indicator was 0.15 and 1.43, respectively.

Based on the data in *Table 1*, we can conclude that the presented index correlates with the IQ index of cities, and is able to reflect the processes of regional formation of the components of the digital twin of a city, regardless of whether the cities of the region participate in the *Smart City* program or not. A value of 1 for such subjects as the Sverdlovsk, Rostov Regions and the Krasnodar Territory is associated with a high proportion of population in the administrative centers of these regions, which took places in the group of *largest cities*.

Table 1. Comparison of regions of the Russian Federation by Iidg for 2019

Entity of the Russian Federation	Iidg	Number of Cities in Top-10 Leaders in IQ Index
Moscow Region	1.43	15
Leningrad Region	0.15	1
Sverdlovsk Region	0.65	1
Krasnodar Territory	0.58	1
Rostov Region	0.32	1
Saratov Region	0.07	0

Source: Compiled by the authors based on the analysis of regional programs of the constituent entities of the Russian Federation

The use of this index would be more effective in combination with a comprehensive tool for assessing the digitalization of public administration, however, its independent development is currently not relevant, due to the work on the creation of such a tool in the Ministry of Digital Development, Communications and Mass Media of the Russian Federation.

4. DISCUSSION

It should be noted that, despite the presence of over 600 works on the issue of digital twins in the RSCI database at the time of this writing, only an extremely insignificant part of them touched upon the issues of modeling the urban environment or the economic aspects of managing digital twins. At the same time, most of the works concern only the definition of the content of the concept of the digital twin of a city or technologies that are potentially applicable for its construction. The results of the analysis of foreign publications in the Web of

Science database made it possible to reveal a similar pattern.

It appears that the reason for the low illumination of this issue in scientific publications is associated with the low level of practical implementation of digital twin technology in practice. At the same time, a certain base for research in this area already exists [11].

So, in a number of regions of the Russian Federation, processes are already underway both to create a regulatory framework for the functioning of digital twins of cities, and to introduce a part of innovative technologies that make it possible to move to modeling the processes of managing a settlement.

As digital governance technologies penetrate into the life of society, more and more new factors will undoubtedly come to light, due to the synergistic effect of the widespread introduction of digital twins, but the role of this work is to initiate research in this direction. In this regard, it is necessary to take into account the potential for a partial change in the interaction of research objects with a significant change in the factors of the interaction environment.

5. CONCLUSION

Based on the research results, we should note the confirmation of the hypothesis according to which the digital twin of the city of regional policy has a significant positive effect on the development of the control subsystem in the area of innovative digital labor tools in public administration.

The above-mentioned achievements of the Moscow Region in the field of creating an environment for developing the digital twin of the city, which are noted in the IQ-cities index, should be reduced to the following factors:

- 1) digitalization of the maximum number of areas of functional activity;
- 2) integration of regional innovative products into the activities of local governments;
- 3) high rates of financing of digitalization processes;
- 4) creation of a system of organizational structures based on the analysis of the results of the work of digital tools.

These prerequisites actually ensure the digitalization of the entire process of local self-government, which, in turn, allows the creation of a

digital twin of the control subsystem, due to the possibility of using tools for the quantitative measurement of labor results. The specified tool, if correctly implemented, is able to ensure that the risk of occurrence of peak loads in individual elements of the organization that provides urban management is taken into account, thereby ensuring the effective distribution of labor resources between various tasks. Due to the limited scope of this article, this factor of the future development of local self-government seems to be a practically significant area of further research.

The results of this study are of practical importance in the context of a prospective assessment of digitalization processes and the creation of conditions for the introduction of digital twins of settlements, the definition of a model for regional digitalization of the activities of public authorities and local self-government.

AUTHORS' CONTRIBUTIONS

Mikhail Ya. Veselovsky, Yury V. Daneykin: general project management, analysis and addition of the text of the article. Maxim A. Sidorov: collection and processing of materials, preparation of the initial version of the text.

REFERENCES

- [1] K. Kourtit, P. Nijkamp, J. Steenbruggen, "The significance of digital data systems for smart city policy", *Socio-Economic Planning Sciences*, 2017, vol. 58, pp. 13-21. DOI: 10.1016/j.seps.2016.10.001
- [2] F. Sussan, Z.J. Acs, "The digital entrepreneurial ecosystem", *Small Business Economics*, 2017, vol. 49, pp. 55-73. DOI: 10.1007/S11187-017-9867-5
- [3] S.A. Ivanov, K.Yu. Nikolskaya, G.I. Radchenko, L.B. Sokolinsky, M.L. Zymbler, "Digital twin of a city: concept overview", *Bulletin of the South Ural State University. Series: Computational Mathematics and Software Engineering*, 2020, vol. 9(4), pp. 5-23. (In Russ.). DOI: 10.14529/cmse200401
- [4] P. Cohendet, D. Grandadam, L. Simon, "The Anatomy of the Creative City", *Industry and Innovation*, 2010, vol. 17, pp. 91-111. DOI: 10.1080/13662710903573869
- [5] K.S. Al-Omouh, V. Simon-Moya, M.A. Al-

- ma'aitah, J. Sendra-Garcia, "The determinants of social CRM entrepreneurship: An institutional perspective", *Journal of Business Research*, 2017, vol. 132, pp. 21-31. DOI: 10.1016/J.JBUSRES.2021.04.017
- [6] V.A. Minaev, A.V. Mazin, K.B. Zdiruk, L.S. Kulikov, "Digital twins of objects in the solution of control problems", *Radio Industry*, 2019, vol. 3, pp. 68-78. (In Russ.). DOI: 10.21778/2413-9599-2019-29-3-68-78
- [7] A.N. Dmitriev, A.N. Sayahova, "Digital twins: use of technology, problems and prospects for development", *Exploring the digitalization of Russia's economy: sectoral aspects [Issledovaniye tsifrovizatsii ekonomiki Rossii: otraslevyye aspekty]*: Proceedings of the student roundtable at the X International SPC dedicated to the 113th anniversary of Plekhanov Russian University of Economics, Moscow, April 08-12, 2020, Ed. by V.I. Resin, Moscow: Plekhanov Russian University of Economics, 2020, pp. 28-36. (In Russ.).
- [8] "Smart city. Cities IQ Index 2019", Ministry of Construction of the Russian Federation, 2020. (In Russ.).
- [9] K. Tomičić-Pupek, I. Pihir, M. Tomičić Furjan, "Smart city initiatives in the context of digital transformation – scope, services and technologies", *Journal of Contemporary Management Issues*, 2019, vol. 58, pp. 39-54. DOI: 10.30924/mjcmi.24.1.3
- [10] L.D. Dzhidzelaeva, A.V. Rodin, "Digital transformation in public governance" ["Tsifrovaya transformatsiya v sfere publchnogo upravleniya"], in *Proceedings of the III ISPC*, 2019, vol. 1, pp. 97-100. (In Russ.).
- [11] D.M. Zhuravlev, "Development and formation of a model for managing innovative development of a subject of the Russian Federation", *Bulletin NGII*, 2020, vol. 10(113), pp. 86-97. DOI: 10.24411/2227-9407-2020-10097