

Smart cities as centers of interregional cooperation

Ali Kahramanoglu¹, Sergey Isaev², Ludmila Glezman^{3*}, and Svetlana Fedoseeva³

¹Ondokus Mayis University, Bafta Business School, Körfez, 19 Mayis Unv., 55270, Atakum / Sumsun, Turkey

²Perm State University, 15 Bukireva St., 614000 Perm, Russia

³Institute of Economics of the Ural Branch of the Russian Academy of Sciences, 50 Lenina St., 61499 Perm, Russia

Abstract. In modern science, the study of digitalization and digital transformation in spatial socio-economic systems, among which urban and regional agglomerations are the most complex ones, plays a special role. The paper considers scientific publications devoted to the problems of smart city development. Russian practices of smart city development are investigated in comparison with the world leaders in urban space digitalization. Based on the analysis of the achieved level of digital transformation of urban space and development of "smart city" technologies in the cities-leaders in the development of "smart" technologies in the subjects of the Russian Federation in 2021, the issue of scaling promising technologies and successful practices from urban to the level of regional space is being considered. The prospects of integrating the smart city as a point of digital development of regional space into the system of inter-regional interactions of digital regions are disclosed.

Key words: Digital space; Smart city; Smart region; Interregional cooperation; Digital economy.

1 Introduction

Digital transformation has been declared the national development goal of the Russian Federation [1]. In the context of cities, the trend of digitalization is realized in "smart city" projects, the interpretation of which is as broad as the meaningful representation. We will understand a "smart city" as a settlement in which the development and improvement of the efficiency of infrastructure and services are based on the application of information technologies and digital solutions to improve the efficiency of resource use, as well as the safety, comfort, environmental friendliness and attractiveness of the living environment of citizens. In other words, a smart city is an integrative ecosystem of physical, digital and human systems created to ensure safe, sustainable and comfortable development of society in the city [2, 3].

* Corresponding author: glezman.lv@uiec.ru

As of today, there are more than 237 "smart city" projects of different efficiency levels in Russia. However, taking into account the Russian federal model of state structure and three-tier model of budgeting (in which the regional level stands above the municipal one), studying "smart cities" it is necessary to take into account the regional aspect, which is due to intra-regional and inter-regional connectivity of socio-economic space. It is important to note that if the research on the diffusion of smart city technologies in the space of regions and the implementation of these processes within the regional space at the inter-municipal level is actively carried out, then theoretical research and practical development in terms of scaling smart city technologies [4] to the inter-regional level in the modern scientific space is virtually absent. In addition, of scientific and practical interest is the problem of building inter-regional connections in the digital space of the new economy, where the center of communication activity is just smart cities with the most developed information and communication and digital infrastructure [5].

Thus, in the context of the development of the digital economy of the Russian Federation amid transformations of economic relations and socio-economic interactions, it is theoretically relevant and practically significant to specify the role of smart cities as centers of interregional interaction. The key objectives of this work are to identify the opportunities for diffusion of smart city technologies and the prospects for their scaling from urban to regional space; to substantiate the role and prospects for positioning smart cities as centers of interaction of smart regions.

2 Literature review

In the process of the global spread of digital technology, the research of modern scientists devoted to the study of the development and functioning of urban areas, digital urban environment and smart cities is becoming more and more significant.

In the scientific literature there is a significant interest in the management of urban development on the basis of advanced innovative solutions, achievements of digitalization and platformization [6], laid in the concept of "Smart City" [7], which requires the development of a long-term strategy [8, 9]. It is also possible to note the works devoted to smart solutions implemented in Russian cities [10].

In recent years, researchers have been paying more and more attention to the implementation of the smart city concept that contributes to sustainable development of territories and economic growth of cities [11], as well as improving the quality of life of the population. Thus, Semyachkov offers a model of sustainable development of urban environment based on digital technology, with the help of which he calculates the index of urban sustainability and develops recommendations to improve the sustainability of territories [12]. Other scientists conduct a systematization of modern approaches to smart sustainable cities [13].

Researchers note that the management solutions of the "smart city" are most effective in combination with hybrid models [14], but their implementation and overcoming the barriers to the development of smart cities require an effective policy [15], as well as continuous adaptation of the management processes of technological, organizational and external risks in sustainable management of smart cities to the dynamic conditions of the new economy [16].

In addition, it can be noted the research aimed at the integrated development of urban economy based on the concept of "Smart City", including engineering infrastructure, urban transport, housing and utilities systems, energy resources [17], innovation for urban environment, smart environmental safety systems, tourism and service [18]. Some scientists propose to consider smart cities of the future as cyber-physical systems, focused on improving urban services and increasing the efficiency of management decisions [19, 20].

The transition from smart cities to digital regions by scaling management networks and creating unified regional platforms is considered in the study of Mukhametov [4].

It is possible to note a number of scientific works devoted to the development of smart cities in different countries. For example, a study on the development of a "smart city" based on the example of Taiwan, focused on citizens' preferences, including "smart" energy, transportation and security [21]. A study of 116 Italian cities, which notes that the policy of "smart cities" is spreading throughout the country, despite the high differentiation of urban development in Italy [22]. In Indonesia the attention of scientists is focused on the study of the key factors influencing the implementation of the concept of integrated management of urban resources "smart city", as well as on assessing the effectiveness of e-government services [23]. The example of the Emirati city Masdar is considered in the article by Cugurullo, where the concept of "smart urbanism" introduces objects with artificial intelligence to manage urban services [24]. For the purposes of this paper of particular interest are the scientific studies of scientists who consider the transformation of the concept of "smart city" and its various models on the example of cities in Turkey [25].

In the Russian scientific literature, practical research aimed at developing various methods of diagnosing and evaluating the development of smart cities is significant. Thus, it is possible to note a rating technique based on the theory of multidimensional comparisons, which makes it possible to assess the dynamics of smart city development, and also allows to make appropriate managerial decisions to improve the sustainability of urban areas [26] and a technique to assess the effectiveness of the introduction of "smart city" technologies, based on the index and integral methods [27].

The analytical review of scientific publications has shown that to date a sufficient theoretical basis for research on the development and functioning of smart cities has been formed. However, the processes of digital transformation in conjunction with globalization lead to the need to scale digital technologies of smart cities to higher level systems (in the federal structure of the Russian Federation, these are regional spaces) and further build interaction between them in the digital space. This task is of high relevance and importance, being insufficiently theoretically studied and practically elaborated due to its novelty.

3 Materials and methods

To solve the tasks set in the research, a review analysis of smart city and region development ratings was used, such as:

- global rating of cities Smart City Index 2021 [28], developed by the IMD Centre for Global Competitiveness and the Singapore University of Technology and Design, defining the smartest city in the world, where high technology and smart solutions are integrated into the daily life of citizens;
- Russian rating Smart City [29], developed by the Ministry of Construction and Housing and Communal Services of the Russian Federation, which determines the level of digital transformation of cities;
- Russian regional ranking SMART [30], developed by the Association of Innovative Regions of Russia, which determines the level of development of Russian regions in order to specify the necessary anti-crisis measures and management decisions.

To identify opportunities for the diffusion of smart city technologies and their scaling from urban to regional space, the comparability of the results of rating studies was analyzed.

To substantiate the role and prospects of positioning smart cities as centers of interaction of smart regions, methods of comparison, comparison, generalization and systematization of publicly available scientific research in the field of rating were used. Analytical data processing was performed using the tools of data aggregation, system analysis, graphical interpretation and data visualization.

4 Results

According to the Smart City Index 2021 [28], the top 100 smart cities in the world include two Russian megalopolises: Moscow (54th place) and St. Petersburg (79th place) and two Turkish cities: Ankara (55th place) and Istanbul (94th) (Table 1).

Table 1. Top 100 Smart Cities of the World in 2021.

No	City	Country	Ranking
1	Singapore	Singapore	AAA
2	Zurich	Switzerland	AA
3	Oslo	Norway	AA
4	Taipei	China	A
5	Lausanne	Switzerland	A
6	Helsinki	Finland	A
7	Copenhagen	Denmark	A
8	Geneva	Switzerland	A
9	Auckland	New Zealand	A
10	Bilbao	Spain	BBB
<...>			
54	Moscow	Russia	B
55	Ankara	Turkey	B
<...>			
79	St. Petersburg	Russia	CCC
<...>			
94	Istanbul	Turkey	CC

Source: compiled by the authors according to Smart City Index 2021. <https://nonews.co/wp-content/uploads/2022/01/SCI2021.pdf> (accessed: 10.05.2023).

The capitals of Russia and Turkey are now at an average level in the rating of smart cities. Given the scale and speed of digitalization of megacities, we can assume that by 2030 both megacities will improve their positions in the ranking.

As for the cities within the country leading in digitalization, the data of the Smart Cities rating [29] are of interest (Table 2).

Table 2. Development of smart cities and regions of the Russian Federation in 2021.

Ranking of smart cities	Cities	Regions	Region ranking SMART
1	Moscow	Moscow	1
2	St. Petersburg	St. Petersburg	2
3	Nizhny Novgorod	Nizhny Novgorod region	5
4	Ufa	Republic of Bashkortostan	12
5	Kazan	Republic of Tatarstan	3
6	Krasnoyarsk	Krasnoyarsk Territory	6
7	Volgograd	Volgograd region	18
8	Chelyabinsk	Chelyabinsk region	37
9	Voronezh	Voronezh region	13
10	Perm	Perm Territory	10
11	Ekaterinburg	Sverdlovsk region	16
12	Samara	Samara region	8
13	Omsk	Omsk region	26
14	Rostov-on-Don	Rostov region	11
15	Novosibirsk	Novosibirsk region	7

Source: compiled by the authors according to Smart City. <https://russiasmartcity.ru/> (accessed: 10.05.2023) and compiled by the authors according to Region ranking SMART. <https://i-regions.org/reiting/rejting-regionov-smart/> (accessed: 10.05.2023).

The Smart City project [29] is aimed at forming an effective system of urban management, creating safe and comfortable living conditions for citizens and improving the competitiveness of Russian cities. Cities are assessed in several areas: urban environment; safe city; digital city management; people's well-being, investment climate. Let us consider the most promising digital technologies of smart cities-leaders of the Russian Federation:

Moscow - Albacore digital ecosystem for managing smart buildings; mobile platform for providing multimedia services and info-communication services in public transport; CarPlace smart parking complex; smart city buildings; Symbiote automated system for controlling and accounting of energy resources; smart containers and Binology level sensors for efficient waste and secondary raw materials management, etc.;

St. Petersburg - a mobile platform for providing multimedia services and info-communication services in public transport; CarPlace smart parking complex; a platform for electronic voting based on distributed registry technologies "CryptoVeche";

Nizhny Novgorod - unified city monitoring system; smart containers and Binology level sensors for efficient waste and secondary raw materials management;

Ufa - Rubin automated information system;

Kazan - smart city buildings on Ujin OS platform; Sirin - artificial intelligence service with computer vision to create a smart yard, city, region;

Krasnoyarsk - smart city buildings on Ujin OS platform; City Online;

Volgograd - passenger information system for public transport and bus stops; software and hardware complex "Monitoring-Predictive";

Chelyabinsk - smart pedestrian crossing - CROSS 1; system of automatic fixation of traffic accidents; smart car parks with the function of virtual signalling; smart lift; virtual assistant (voice robot, chatbot); environmental monitoring system, etc.;

Voronezh - automated system for control and accounting of transport work;

Perm - a platform for collecting and analysing parameters of traffic flows and pedestrians from video surveillance cameras in real time; smart city buildings digital environment on the Ujin OS platform; automation of vehicle entry-exit;

Ekaterinburg - service of automated monitoring of housing and communal services "Digital Ombudsman of the Resident"; smart city buildings digital environment on the Ujin OS platform;

Samara - Integra 4D-Planet Earth integration platform for implementation of Safe and Smart City projects;

Omsk - "Smart Light"; "Smart Intercom";

Rostov on Don - smart city buildings, digital environment on the Ujin OS platform; concept of introducing a unified billing platform based on the software product "Settlements for housing and communal services";

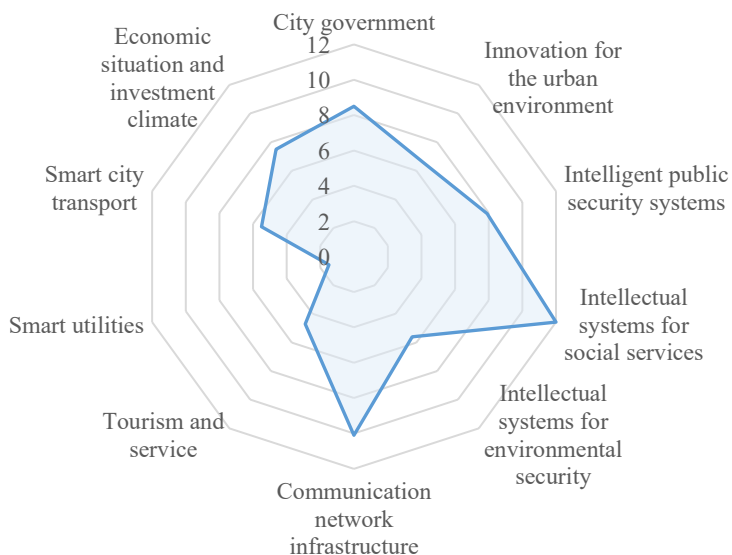
Novosibirsk - smart bus stops; unified electronic registrar for doctor's appointments [29].

Based on the intra-regional connectivity of the development of the territories of the region [31], the socio-economic development of cities in the aggregate determines the level of development of the socio-economic space of the region. In the context of digital transformation, it is fair to believe that successful digital solutions and promising technologies implemented in the region's cities can be scaled for the digitalization of the regional space in order to create a "smart region". The implementation of smart city technologies in the regional space is identical to the implementation of digital technologies and the creation of digital infrastructure in the region. The problems of creating and developing "smart regions" are less studied. However, we believe that the formation and development of digital regions should be similar to the creation of smart cities located in their

space and taking into account regional specialization and territorial features. In other words, platform solutions, digital services and technologies implemented and successfully operating in the region's smart cities can be scaled to the entire regional space and integrated into a single digital platform - the "smart region".

Thus, smart cities are the basis for the digital development of regions, in the Russian Federation such cities are, as a rule, regional centers. On this basis, we carried out a comparative analysis of the rating of smart cities and the SMART rating of the corresponding regions [30] (Table 2). According to the results of the analysis, it is obvious that the development level of most regions according to the SMART rating indicators (science policy, media policy, anti-crisis policy, regional policy/resilience, technological policy) corresponds to the rating of smart cities which are their regional centers, which confirms the hypothesis about the possibility and feasibility of scaling digital technologies and services from urban to regional space, thus providing an accelerated digital development of regional space.

The effectiveness of intra-regional diffusion of smart city technological solutions will be justified by the example of the Perm Territory, which ranks 10th in the rating of the most innovative and digital regions of the Russian Federation. The regional capital, Perm, has been in the top 10 smart cities for the second year in a row in the category "Largest cities with more than 1 million people" (Fig. 1).



Source: compiled by the authors according to Smart City. <https://russiasmartcity.ru/> (accessed: 10.05.2023).

Fig. 1. Distribution of Perm's performance by IQ-city rating segments in 2021.

In 2018, Perm was included in the list of 18 pilot cities from 15 regions of the country to implement the "Smart City" project. Having developed and implemented smart city technologies in the regional center, the regional government supported the diffusion of successful technologies and solutions for scaling digitalization in large, medium and small cities of Perm krai, in total there are 14 municipalities in the region included in the "Smart City" project. The effectiveness of the intraregional approach to scaling smart city technologies is confirmed by the fact that most cities of Perm Krai have been included in the rating of smart cities (Solikamsk, Chaikovsky, Berezniki, Nytva and Lysva).

By the beginning of 2023, more than 52% of the region's municipalities will be involved in the Smart City project. As part of the transition from the city management strategy to the

regional management strategy, the regional government plans to include all cities of Perm Krai in the project by the end of the year, which will make it possible:

- form a unified program of strategic digital development of the region, uniting digitalization projects of municipalities at the regional level;
- ensure the unity of information systems at the federal, departmental, municipal, commercial, and other levels through a single integrative digital platform;
- correspond to the key trends of the federal agenda and the global challenges of digital transformation.

Summarizing the above, it is fair to believe that cities that have succeeded in implementing smart technologies can act as guides for digital solutions for municipalities of other constituent entities of the Russian Federation, ensuring and developing regional interaction in the digital space based on the exchange and diffusion of digital technologies.

However, it is necessary to take into account new challenges that, on the one hand, play the role of constraints in the development of smart cities and regions, and, on the other hand, contribute to the technological development of the Russian economy. For example, such factors include high instability and uncertainty in the global economic system, sanctions pressure from a number of unfriendly countries, geopolitical confrontation and the resulting economic processes - restriction of supplies of high-tech products, temporary cessation of activities of many foreign companies in the Russian market. Therefore, to ensure the possibility of developing and implementing projects of smart cities and smart regions in the Russian Federation, a consistent and coordinated state policy of import substitution and achieving technological sovereignty is necessary, in the context of which the need to develop advanced innovative technologies, high-tech products, domestic software is actualised. Which will contribute to ensuring national security and preserving the economic and political sovereignty of the Russian Federation.

5 Conclusion

The study has shown that the most promising strategy for the formation and development of smart regions is the scaling of successful digital practices and solutions tested at the level of smart cities. The advantages of this approach are as follows: targeted analysis of the feasibility of implementation and the possibility of selecting the most successful and well-established digital technologies and solutions tested at the level of smart cities; development of a smart region as an integrative integrated platform of digital solutions, technologies and tools for managing the development of smart cities and territories, regardless of their scale.

The center of competence of digital technologies and solutions are the most successful smart cities, the best practices of which, with the support of the state, can be replicated in the municipalities of other constituent entities of the Russian Federation with a lower level of digital development.

As recommendations from the study, it is advisable to recommend the development of a unified integrated approach and tools to assess the development of cities and regions in terms of the implementation and use of smart technologies, which will allow to form an objective picture of the level of development of smart regions and cities.

Acknowledgments

The work was performed in accordance with the Research Plan of the Institute of Economics of the Ural Branch of the Russian Academy of Sciences.

References

1. Target indicators of the Russian Federation's national development goal "Digital Transformation" have been defined, <https://d-russia.ru/opredeleny-celevye-pokazateli-nacionalnoj-celi-razvitiya-rf-cifrovaja-transformacija.html>. Accessed 10 May 2023
2. Y. Kostrova, Waste and Resources **9** (2022) <https://doi.org/10.15862/07ECOR322>
3. O. Burmatova, ECO **6**,139 (2021) <https://doi.org/10.30680/ECO0131-7652-2021-6-139-160>
4. D. Mukhametov, Voprosy innovatsionnoy ekonomiki **11**, 141 (2021) <https://doi.org/10.18334/vinec.11.1.111804>
5. A. Veselova, A. Hatzkelevich, L. Ezhova, Perm University Herald. Economy **13**, 75 (2018) <https://doi.org/10.17072/1994-9960-2018-1-75-89>
6. L. Westraadt, Sustainable Cities and Society **63**, 102444 (2020) <https://doi.org/10.1016/j.scs.2020.102444>
7. M. Alyabieva, O. Belokopytova, I. Gasho, Herald of the Belgorod University of Cooperation, Economics and Law **2**, 21 (2022) <https://doi.org/10.21295/2223-5639-2022-2-21-33>
8. O. Patrakeeva, Social entrepreneurship and corporate social responsibility **3**, 125 (2022) <https://doi.org/10.18334/social.3.2.115021>
9. J. Kandt, M. Batty, Cities **109**, 102992 (2021) <https://doi.org/10.1016/j.cities.2020.102992>
10. K. Krinichanskii, Regional Economics: Theory and Practice **17**, 926 (2019) <https://doi.org/10.24891/re.17.5.926>
11. E. Karagulyan, O. Zakharova, M. Batyрева, D. Dusseault, Russian Journal of Economic Theory **17**, 657 (2020) <https://doi.org/10.31063/2073-6517/2020.17-3.11>
12. K. Semyachkov, Voprosy innovatsionnoy ekonomiki **11**, 1015 (2021) <https://doi.org/10.18334/vinec.11.3.113448>
13. N. Vukovic, V. Larionova, P. Morganti, Economy of region **17**, 1004 (2021) <https://doi.org/10.17059/ekon.reg.2021-3-20>
14. S. Secinaro, V. Brescia, D. Calandra, P. Biancone, Cities **116**, 103278 (2021) <https://doi.org/10.1016/j.cities.2021.103278>
15. A. Razmjoo, P. A. Østergaard, M. Denai, M. M. Nezhad, S. Mirjalili, Energy Research & Social Science **79**, 102175 (2021) <https://doi.org/10.1016/j.erss.2021.102175>
16. F. Ullah, S. Qayyum, M. J. Thaheem, F. Al-Turjman, S. M. E. Sepasgozar, Technological Forecasting and Social Change **167**, 120743 (2021) <https://doi.org/10.1016/j.techfore.2021.120743>
17. A. Dzyuba, I. Solovyeva, Upravlenets – The Manager **11**, 53 (2020) <https://doi.org/10.29141/2218-5003-2020-11-2-5>
18. V. Dubrovzky, E. Rozhkov, Economics. Sociology. Law **4**, 9 (2022) <https://doi.org/10.22281/2542-1697-2022-01-04-09-19>
19. A. Puliafito, G. Tricomi, A. Zafeiropoulos, S. Papavassiliou, Sensors **21**, 3349 (2021) <https://doi.org/10.3390/s21103349>
20. D. Chen, P. Wawrzynski, Z. Lv, Sustainable Cities and Society **66**, 102655 (2021) <https://doi.org/10.1016/j.scs.2020.102655>
21. T. Ji, J.-H. Chen, H.-H. Wei, Y.-C. Su, Sustainable Cities and Society **67**, 102691 (2021) <https://doi.org/10.1016/j.scs.2020.102691>
22. E. Ivaldi, L. Penco, G. Isola, E. Musso, Social Indicators Research **150**, 45 (2020) <https://doi.org/10.1007/s11205-020-02292-0>

23. A. Darmawan, D. Siahaan, T. Susanto, Hoiriyah, B. Umam, B. Bakir, in 3rd International Conference on Information and Communications Technology (ICOIACT), 234-239 (2020) <https://doi.org/10.1109/ICOIACT50329.2020.9332140>
24. F. Cugurullo, *Frontiers in Sustainable Cities* **2**, 38 (2020) <https://doi.org/10.3389/frsc.2020.00038>
25. G. Altindas, K. Velibeyoglu, in *Architecture, Innovation Technology (ATI) 2020: Smart Buildings, Smart Cities* (2020), pp. 262-269
26. E. Lyaskovskaya, T. Khudyakova, A. Shmidt, *Economy of regions* **18**, 1046 (2022) <https://doi.org/10.17059/ekon.reg.2022-4-6>
27. M. Tsybareva, V. Vasyaicheva, *Vestnik of Samara University. Economics and Management* **11**, 83 (2020) <http://doi.org/10.18287/2542-0461-2020-11-2-83-91>
28. Smart City Index 2021, <https://nonews.co/wp-content/uploads/2022/01/SCI2021.pdf>. Accessed 10. May 2023
29. Smart City, <https://russiasmartcity.ru/>. Accessed 10 May 2023
30. Region ranking SMART. <https://i-regions.org/reiting/rejting-regionov-smart/>. Accessed 10 May 2023
31. I. Danilova, I. Savelyeva, A. Rezepin, *Economy of regions* **18**, 31 (2022) <https://doi.org/10.17059/ekon.reg.2022-1-3>