National Research University Higher School of Economics

As a manuscript

Kirill Sergeevich Tyurchev

Cluster Approach to the Management of City Innovation Systems: The Case of Moscow

PhD Dissertation Summary

for the purpose of obtaining an academic

degree Doctor of Philosophy in Public

Administration

Academic Supervisor:

Candidate of Sciences in Economics

Evgeniy Sergeevich Kutsenko

Moscow 2024

Relevance of the topic, previous studies[1]

Innovation is one of the key factors of economic growth, and improved well-being [Solow, 1956; Romer, 1986]. At the same time lack of a systemic approach to understanding the innovation process often results in ineffective policies aimed at promoting innovation in the real sector of the economy [Nelson, Winter, 1977]. The first attempts to systemically describe key innovation actors in different countries can be found in early reviews and methodological recommendations published by the Organisation for Economic Cooperation and Development (OECD), and in analytical reports of the RAND Corporation [Hughes, Hughes, 2011].

In the late 1980s the national innovation system (NIS) concept was suggested, which provided a comprehensive view of the main participants in the innovation process, and became the basis for developed countries' science and technology policies [Freeman, 1982; Lundvall, 1985; Nelson, 1981]. E.g. the Triple Helix model has become popular in management practices: it describes various formats and options for interaction between universities, companies, and the state in the scope of the innovation process [Leydesdorff, Etzkowitz, 1998].

As the growing role of specific regions in the world economy became increasingly apparent, the regional innovation system (RIS) concept began to take shape [Ōmae, Ohmae, 1995]. It explained the greater economic efficiency of some areas compared to others, and became the basis for implementing regional innovation policies. E.g. the RIS concept provided the foundation for smart specialisation policy, which eliminated the duplication of responsibilities for implementing innovation policies between national and regional authorities in the European Union, and reduced the

[1] This thesis includes fragments of research published by the author in the form of academic papers, including the following ones: Tyurchev, K. (2021). Managing innovation systems: from national to local level. *Issues of Public and Municipal Administration*, (4), 185–206 (in Russian); Tyurchev, K. (2022). Is Information Openness Important for Innovation Infrastructure? Research of Technoparks in Moscow. *The Innovation Journal*, 27(2), 2–18; Kutsenko, E., Tyurchev, K., Ostashchenko, T. (2022). Relocation as a Driver of Innovative Activity: A Global Study of Unicorn Founders' Migration. *Foresight and STI Governance*, 16(4), 6–23.

dispersion of public funds between numerous uncoordinated science, technology, and industry priorities [European Commission, 2012; Fitjar et al., 2019].

At the same time studies of the spatial distribution of innovations reveal a high concentration of the latter in specific localities: cities and urban agglomerations [Hall, 1998; Bettencourt et al., 2007]. Many authors attribute this to the fact that key innovation economy players, such as large companies, technology start-ups, and educational and research organisations are located in cities [Harmancioglu, Tellis, 2018].

In recent decades a number of theoretical approaches have emerged, which provide frameworks for studying cities and their governance models. Among them are the sustainable city [Niemets et al., 2021], smart city [Eremia et al., 2017], green city [Brilhante, Klaas, 2018], intelligent city [Komninos, 2009] concepts, etc. Their common feature is recognising the importance of the knowledge-based development principle. However, despite these concepts' practical applicability and popularity among managers, they do not offer any universal models for objectively comparing cities, and identifying the weaknesses and strengths of their innovation systems. Therefore they cannot serve as tools for shaping city level evidence-based innovation policies [Tyurchev, 2021; Shearmur, 2012]

This has led to an increase in the number of studies of city (local) innovation systems. The authors of these studies note that this approach appears to be more promising in terms of practical application to management purposes than similar studies at the regional or national levels [Boschma et al., 2014]. At the same time the research of city innovation systems is hindered by a number of issues, in particular:

- Lack of consensus on the nature and scope of the innovation concept applied in the context of city development [Christmann, 2020].
- Lack of reliable data sources for international comparison of cities based on the level of their innovation systems [Wong at al., 2018].

- Different understanding of cities and urban areas in different countries [Shi et al., 2019].

Also, some authors note the lack of local authorities' competencies and resources to promote innovation; these agencies tend to focus on maintaining urban infrastructure (social, municipal, transport, etc.) [Boykova et al., 2016]. As a result, city authorities often find themselves outside the scope of innovation policy. It is also noted that local authorities frequently lack a vision of the city's innovation system, its development prospects and priorities [Ravetz, Miles, 2016].

Ignoring specific features of a particular city and its innovation system, and trying to copy best innovation-based development practices often result in shaping erroneous innovation policies and lead to negative consequences [Van Winden, 2008]. Therefore identifying various types of city innovation systems becomes relevant, to develop more appropriate management models for them [Cherubini et al., 2021].

In actual practice, clusters have become one of the most popular tools for implementing innovation policy at the regional and local level [Porter, 2000; Huggins, Isushi, 2015]. Their main advantage is that, unlike the sectoral approach, they allow to take into account the links between organisations, and the resulting effects in the form of new technologies, skills, and knowledge. Subsequent empirical studies showed the advantages of the cluster approach to economic management in terms of innovation development compared to the traditional sectoral one [Orsenigo, 2001]. Accordingly, clusters and the cluster approach have been integrated not only in industrial, but also in innovation policy [Abashkin et al., 2012; Kutsenko, 2015]. The cluster approach to managing a city innovation system allows to cover a wide range of innovation actors including various industry leaders, representatives of the entire value chain, and of other elements of the city innovation system. This is especially important in the city economy context, given the spatial proximity of a large number of economic agents. Meanwhile digitalisation of cluster activities

increases the coverage of city organisations, and of the services they provide even further [Ravarini et al., 2013; Babkin et al., 2022].

Domestically, during the Soviet period cooperation between various innovation system participants was promoted, among other ways, by setting up research and production associations (RPAs) comprising R&D organisations and enterprises with a high design and experimentation capacity [Khmelevoy, Naydenov, 2016]. To increase the science and technology potential, RPAs together with other enterprises and organisations could be included in larger organisational structures, namely state production associations. In a number of cases RPAs were established in close proximity to large urban agglomerations (primarily Moscow), and later on, in the Russian Federation, were given the status of "science towns" [Sibiryaev, 2015]. Currently, to promote the commercialisation of intellectual property and cooperation between science and business, Innovation Science and Technology Centres (ISTCs) based on higher education organisations are being established in addition to science towns. Also, a new legal institute is emerging: territories of high S&T potential (STP) concentration.[2] A particular layer of studies is devoted to the innovation-based development of the City of Moscow [Mitienko et al., 2021; Balakhonova, 2023], and the management of its science and technology complex [Gokhberg, 1986; Dmitriev, 2013].

Different formats of innovation-based development territories complicate the shaping of innovation policies [Gokhberg, Kuznetsova, 2011], which in turn creates the need to conduct an in-depth analysis of possible models and tools for managing city innovation systems.

[2] Proceedings of the online conference hosted by the RF Ministry of Science and Higher Education "Current issues in the development of science cities in the Russian Federation: municipalities with a special status." [electronic source] URL: http://council.gov.ru/media/files/n2r3g1gmn3SOV6Vfa5iVVJjfvAyI9bV7.pdf (accessed on: 30.05.2023).

Goal, objectives, object, and subject of the study

The **goal** of this dissertation study is to identify various types of city innovation systems, and then apply the results obtained to manage city innovation systems on the basis of the cluster approach, using Moscow as an example.

To achieve this goal, the following **objectives** were set:

- clarify the definition and structure of a city innovation system;
- identify various types of city innovation systems, and appropriate management models for them.
- develop mechanisms to improve the management of Moscow city innovation system based on the cluster approach.

Object of the study

The object of this dissertation study is city innovation systems.

Subject of the study

The subject of this dissertation study is the peculiarities of management of city innovation systems of different types

Empirical basis of the study

The empirical basis of the study comprises the following:

- Data sources on the elements of city innovation systems are international platforms, aggregators and ratings, including: a list of 2,500 public companies with the highest research and development costs R&D Scoreboard, a database on participants in the Crunchbase venture market, ratings of the world's leading higher education organizations Quacquarelli Symonds (QS), Times Higher Education (THE), Academic Ranking of World Universities (ARWU), ranking of the largest Scimago research organizations..

- Databases on city population, gross metropolitan product (GMP) (Euromonitor), and patent applications (PATSTAT Global).
- Strategic development documents of cities with the most advanced innovation systems.

Methodology of the study

To assess the impact of various city innovation systems' specific elements on the per capita GMP, ordinal logistic regression will be used in the dissertation study; indexing and ranking techniques will be applied to assess the level of city innovation systems; statistical relationship between the levels of city innovation systems, GMP, and invention activity will be established with the help of correlation analysis; different types of city innovation systems will be identified by conducting fuzzy-set qualitative comparative analysis (fsQCA). Statistical analysis of primary data and desk research were also applied in the course of the study, to analyse cities' development strategies.

Main results presented for defence

1. The need to update the city innovation system concept was substantiated, based on the results of studying spatial dissemination of innovations and their tendency to concentrate in a small number of locations, and authorities' need for a convenient theoretical framework and a model to manage innovation-based city development. An original definition of a city innovation system, and a relevant theoretical model were proposed; the possibility to apply the cluster approach to managing city innovation systems was substantiated.
2. In line with the developed theoretical model, a comprehensive analysis of the Moscow City innovation system was carried out, comparing it with those of other cities. The identified strengths of the Moscow innovation system include a significant presence of leading educational and research organisations, high research activity, high concentration of domestic and

foreign students, a significant number of start-ups, developed physical infrastructure (clusters, technology and science parks, co-working spaces). The weaknesses include small number of leading researchers, low invention activity, an incomparably smaller number of major technology companies than in other leading global cities, the lack of unicorn companies, a small number of venture capitalists and business angels, and insufficiently developed digital infrastructure.

3. 1,176 city innovation systems in 102 countries were assessed based on the presence of key innovation actors (major technology companies, unicorn firms, leading educational and research organisations), in line with the theoretical model proposed by the author. Ordinal logistic regression analysis revealed that the presence of city innovation system elements allows to correctly determine the per capita GMP with 75.6% accuracy. This suggests the suitability of the proposed approach for assessing the development of city innovation systems, if the above economic indicator is set as its management goal. Analysis of the city development estimates' distribution suggests the presence of the power law, previously identified for cities based on patenting and academic publications data, which does not contradict the results obtained earlier, and confirms stability of the approach proposed by the author.
4. 16 types of city innovation systems were identified using fsQCA analysis. University-based ones (108 cities), combined university/research (57), and research-based (40) innovation systems can be considered the most common types. 5 of the 16 types can be classified as niche ones, since they were discovered in only 18 cities. In 35 cities a significant presence of all city innovation system elements was found; each of these cities is in the top 50 in terms of the innovation system level. The same cities account for 54.8% of major technology companies, and 71.8% of unicorn firms. Each of the identified city innovation system types has a particular management model.

5. The directions to improve the cluster development mechanisms for the Moscow innovation system were determined, based on studying the experience of the Moscow innovation cluster, the identified strengths and weaknesses of the city innovation system, and analysis of strategic development documents of cities with the most advanced innovation systems. In particular, it is suggested to increase the number of cluster participants by involving creative organisations; expand the membership in the Moscow Innovation Cluster's Supervisory Board by inviting representatives of private innovative companies, cities' professional communities, international cluster and innovation associations; use the cluster's digital platform to collect voluntarily disclosed information about member organisations; publish summary data on the state of the city innovation system; and give the cluster responsibilities to implement various federal innovation support initiatives.

Original scholarly contribution

The results of this dissertation study make original scholarly contributions to various areas, in particular:

- The author's definition of the city's innovation system is proposed, which, in comparison with existing ones, allows to more accurately reflect its essence and structure. This was achieved, in particular, by supplementing the definition with elements of the innovation infrastructure, as well as by authorities at different levels.
- A model of the city's innovation system has been developed, which most broadly reflects the key participants in the innovation process and the links between them, which can be used by authorities at different levels to solve the tasks of managing the city's innovation system.
- A database on the elements of innovation systems of 1,176 cities from 102 countries of the world, as well as their additional characteristics (population,

GDP, number of patent applications for inventions) has been formed and put into research circulation.

- Based on the method of qualitative comparative analysis based on fuzzy sets (fsQCA), 16 types of innovative urban systems have been identified, for each of which management models have been defined: the traditional sectoral, the developing cluster model and the urban super cluster model. The proposed management models are further differentiated into the following categories: the distribution of powers between management levels and the degree of centralization of decision-making, priorities for the allocation of public resources, and risk allocation.
- Based on the analysis of strategic development documents of 30 leading cities in terms of the development of innovative systems, key priorities and mechanisms for their innovative development have been identified, including the use of a cluster approach in management, the creation of modern physical (including digital) infrastructure, and the involvement of innovators (personalities and organizations) from other cities of the world.
- The directions of improving the mechanisms of cluster development of the Moscow innovation system have been identified based on the study of the experience of the Moscow Innovation cluster, the identified strengths and weaknesses of the city's innovation system, and the analysis of documents for the strategic development of cities – leaders in the development of innovative systems. In particular, it is proposed to expand the list of cluster participants by organizations of the creative sector of the economy, expand the composition of the supervisory board of the Moscow Innovation Cluster by including representatives of private innovative companies, professional communities of cities and international cluster and innovation associations, use the cluster's digital platform to collect voluntarily disclosed information about organizations – to publish summary data on the state of the city's innovation system, to use the Cluster as an operator of a number of federal measures to support innovation.

Practical importance

The practical importance of this dissertation study lies in the possibility to apply the obtained empirical results to improve the management of the Moscow innovation system. The analysis of Moscow's innovation system in comparison with other cities, based on a unified indicator system, can be useful for regional authorities responsible for Moscow's innovation-based development, to set and substantiate development priorities for the city. The thesis includes recommendations to more efficiently apply the cluster approach to managing Moscow's innovation system, taking into account the available relevant experience.

In a broader context, the results of the study can help identify innovation development centres in various countries of the world, and choose the most suitable models for managing them.

Limitations and directions for further research

The limitations of the study include the use of data for only two periods. Considering data over a longer time period would allow for a more accurate assessment of the transition of innovative urban systems from one type to another. Another limitation of the study is the lack of any quantitative data reflecting the efforts of different levels of government (national, regional and local) to develop innovative urban systems in the context of cross-country comparisons.

The results of the dissertation research can serve as a starting point for conducting research in the following areas:

- Clarification of the types of urban innovation systems through the use of additional indicators (for example, related to innovation policy or the development of so-called non-technological innovations).
- Deeper study (case study) of certain types of innovative urban systems, search for features and patterns of their development.

- Studying the mobility of elements of urban innovation systems and related policies.

Structure and scope of the thesis

The structure and scope of the thesis reflect the general logic of the study; it comprises introduction, three chapters, conclusion, a list of references, and eight appendices. The bibliography includes 239 titles of domestic and foreign sources. The thesis has 214 pages, with 32 tabular and 33 graphical representations.

Evaluation of research results

The main provisions and conclusions of the dissertation study were presented at a number of academic conferences, namely:

1. XXII Yasin (April) International Academic Conference on Economic and Social Development (Moscow, 2021). Report “Emergence of New Industries in Russian Regions: Role of Path Dependencies, Megacities, and Policies”.
2. International Conference on Sustainable Cities and Urban Landscapes (2022). Report “Inside the Creative Pyramid. What Draws World Creativity Leaders to Certain Cities?”
3. International academic symposium “Foresight and Science, Technology, and Innovation Policy” (2022). Report “Global Research of the Unicorn Companies’ International Migration”.
4. International academic symposium “Foresight and Science, Technology, and Innovation Policy” (2022). Report “Who Feeds the Unicorns? Cross-Country Analysis of the Venture Capital Flows”.
5. International academic symposium “Foresight and Science, Technology, and Innovation Policy” (2023). Report “HSE Global Cities Innovation Index GCII 2023: key discoveries, and the history of creation”.

The author's main publications on the topic of the thesis

The most important results of the dissertation study are presented in 5 papers published in Scopus-indexed journals and included in the HSE B and C lists:

1. Tyurchev, K. Managing innovation systems: from national to local level. *Public Administration Issues*, 4, 2021, pp. 185–206 (in Russian). – 1.3 author's sheets (personal contribution 1.3 a.s.) (HSE List C; Q4, 2021).[3]
2. Tyurchev, K. (2022). Is Information Openness Important for Innovation Infrastructure? Research of Technoparks in Moscow. *The Innovation Journal*, 27(2), 2–18. – 1.0 author's sheets (personal contribution 1.0 a.s.) (HSE List C; Q3, 2022[4]).
3. Kutsenko, E., Tyurchev, K., Ostashchenko, T. (2022). Relocation as a Driver of Innovation Activity: A Global Study of Unicorn Founders' Migration. *Foresight and STI Governance*, 16(4), 6–23. – 1.2 author's sheets (personal contribution 0.4 a.s.) (HSE List B; Q2, 2022[5]).
4. Kutsenko, E., Tripathi, S., Tyurchev, K. (2023). Does complementarity affect the emergence of new specialisation industries in Russian regions? *Regional Science Policy and Practice*, 15(9), 2126–2155. – 1.8 author's sheets (personal contribution 0.6 a.s.) (HSE List C; Q2, 2022[6]).
5. Kutsenko, E., Boyakova, K., Ostashchenko, T., Tyurchev, K., Artemov, S. (2024). When size does not matter: Innovation attractiveness factors of medium-sized cities. *Voprosy Ekonomiki*, 6, 96–119. 1.6 author's sheets (personal contribution 0.3 a.s.) (HSE List B; Q1, 2023[7]).

The total volume of publications by the applicant is 6.8 author's sheets; his personal contribution is 3.6 author's sheets.

---

[3] Issues of Public and Municipal Administration Scimago profile. URL: https://www.scimagojr.com/journalsearch.php?q=21100778766&tip=sid&clean=0 (accessed on : 25.08.2023).
[4] The Innovation Journal Scimago profile. URL: https://www.scimagojr.com/journalsearch.php?q=18100156705&tip=sid&clean=0 (accessed on: 25.08.2023).
[5] Foresight and STI Governance Scimago profile. URL: https://www.scimagojr.com/journalsearch.php?q=21100775412&tip=sid&clean=0 (accessed on: 25.08.2023).
[6] Regional Science Policy and Practice Scimago profile. URL: https://www.scimagojr.com/journalsearch.php?q=21100435556&tip=sid&clean=0 (accessed on : 25.08.2023).
[7] Voprosy Ekonomiki Scimago profile. URL: https://www.scimagojr.com/journalsearch.php?q=23452&tip=sid&clean=0 (accessed on : 25.08.2023).

The dissertation study matches the provisions of the Passport of Research Area “Public and Municipal Administration” in terms of paragraphs 7.3. "Public administration in healthcare, education, culture, science and other spheres and industries", 8.2 "Sustainable regional and urban development".

LIST OF REFERENCES

Abashkin V., Boyarov A., Kutsenko E. Cluster Policy in Russia: From Theory to Practice [In Russian] // Foresight and STI Governance. 2012. T. 6, N 3. P. 16–27.

Babkin A., Tashenova L., Mamrayeva D., Shkarupeta Y., Karimov D. Digital Platforms for Network Innovation-Intensive Industrial Clusters: Essence and Characteristics // International Journal of Technology. 2022. Vol. 13(7). P. 1598–1606.

Balakhonova E. Innovative development of smart cities as a necessary condition for achieving the goals of sustainable development [In Russian] // Modeli, sistemy, seti v ekonomike, tekhnike, prirode i obshchestve. 2023. T. 1, N 45. P. 37–55.

Bettencourt L., Lobo J., Strumsky D. Invention in the city: Increasing returns to patenting as a scaling function of metropolitan size // Research policy. 2007. Vol. 36(1). P. 107–120.

Boschma R., Balland P., Kogler D. Relatedness and technological change in cities: the rise and fall of technological knowledge in US metropolitan areas from 1981 to 2010 // Industrial and corporate change. 2014. Vol. 24(1). P. 223–250.

Boykova M., Ilina I., Salazkin M. Smart development model as a response to emerging challenges for cities // Foresight and STI Governance. 2016. Vol. 10(3). P. 65–75.

Brilhante O., Klaas J. Green city concept and a method to measure green city performance over time applied to fifty cities globally: Influence of GDP, population sise and energy efficiency // Sustainability. 2018. Vol. 10(6). P. 2031.

Cherubini Alves A., Fischer B., Vonortas N. Ecosystems of entrepreneurship: configurations and critical dimensions // The Annals of Regional Science. 2021. Vol. 67. P. 73–106.

Christmann G. Introduction: Struggling with innovations. Social innovations and conflicts in urban development and planning // European Planning Studies. 2020. Vol. 28(3). P. 423–433.

Dmitriev A. Regional peculiarities of the management of industrial and scientific potential (on the example of Moscow) [In Russian] // Вестник евразийской науки. 2013. Vol. 3(16). P. 12.

Eremia M., Toma L., Sanduleac M. The smart city concept in the 21st century // Procedia Engineering. 2017. Vol. 181. P. 12–19.

European Commission (2012). Guide to Research and Innovation Strategies for Smart Specialisations. URL: https://s3platform.jrc.ec.europa.eu/en/w/guide-on-research-and-innovation-strategies-for-smart-specialisation-ris3-guide- (дата обращения: 05.07.2023).

Fitjar R., Benneworth P., Asheim B. Towards regional responsible research and innovation? Integrating RRI and RIS3 in European innovation policy // Science and Public Policy. 2019. Vol. 46(5). P. 772–783.

Freeman C. Innovation and long cycles of economic development // Paper Presented at the Internacional Seminar on Innovation and Development at the Industrial Sector. 1982. P. 1–13.

Gokhberg L. Pre-planned justification for the development of science in the city (on the example of Moscow) [In Russian]. Abstract of the dissertation for the degree of Candidate of Economic Sciences; Executive Committee of the Moscow City Council of People's Deputies, Institute of Economic Problems of the Integrated Development of the National Economy of Moscow. – Moscow, 1986. – 24 pp.

Gokhberg L., Kuznetsova T. Strategy 2020: New outlines of Russian innovation policy [In Russian]// Foresight and STI Governance. 2011. Vol. 5(4). P. 8–30.

Hall P. (Eds.). Cities in civilisation. New York, Pantheon Books, 1998.

Harmancioglu N., Tellis G. Silicon envy: How global innovation clusters hurt or stimulate each other across developed and emerging markets // Journal of International Business Studies. 2018. Vol. 49. P. 902–918.

Huggins, R. Isushi H. The Competitive Advantage of Nations: origins and journey // Competitiveness Review. 2015. Vol. 25(5). P. 458–470.

Hughes A., Hughes T. (Eds.). Systems, experts, and computers: The systems approach in management and engineering, World War II and after. Cambridge, MIT Press Books, 2011.

Khmelevoy V., Naydenov A. definition of optimum structure of research-and-production associations for creation of complex technical systems [In Russian] // Journal of Economy and entrepreneurship. 2016. Vol. 11(2). P. 171–174.

Komninos N. Intelligent cities: Towards interactive and global innovation environments // International Journal of Innovation and regional development. 2009. Vol. 1(4). P. 337–355.

Kutsenko E. Pilot innovative territorial clusters in Russia: A sustainable development model [In Russian] // Foresight and STI Governance. 2015. Vol. 9(1). P. 32–55.

Leydesdorff L., Etzkowitz H. Triple Helix of innovation: introduction // Science and Public Policy. 1998. Vol. 25(6). P. 358–364.

Lundvall B.-Å. Product innovation and user-producer interaction // The Learning Economy and the Economics of Hope. 1985. Vol. 19. P. 19–60.

Mitienko M., Odintsova A., Semykina D. Analysis of the level of innovation development of Moscow and St. Petersburg [In Russian] // Student Science Questions. 2021. Vol. 1(53). P. 31–38.

Nelson R. Research on productivity growth and productivity differences: Dead ends and new departures // Journal of economic literature. 1981. Vol. 19(3). P. 1029–1064.

Nelson R., Winter S. In search of a useful theory of innovation. In Innovation, Economic Change and Technology Policies: Proceedings of a Seminar on Technological Innovation. Basel, Birkhäuser. 1977. P. 215–245.

Niemets K., Kravchenko K., Kandyba Y., Kobylin P., Morar C. World cities in terms of the sustainable development concept // Geography and Sustainability. 2021. Vol. 2(4). P. 304–311.

Ōmae K., Ohmae K. (Eds.). The end of the nation state: The rise of regional economies. New York, Simon and Schuster, 1995.

Orsenigo L. The (failed) development of a biotechnology cluster: The case of Lombardy // Small Business Economics. 2001. Vol. 17. P. 77–92.

Porter M. E. Location, competition, and economic development: Local clusters in a global economy // Economic development quarterly. 2000. Vol. 14(1). P. 15–34.

Rasmussen B. Developing the biomedical industries in Canada and Australia: an innovation systems approach. Pharmaceutical Industry Project Working Paper Series. Victoria University of Technology, 2005.

Ravarini A., Pacicco L., Strada E. Industrial clusters evolution enabled by digital platforms: a framework. Italian conference on information systems: Empowering society through digital innovations, 2013.

Ravetz J., Miles I. Foresight in cities: On the possibility of a strategic urban intelligence // Foresight and STI Governance. 2016. Vol. 18(5). P. 469–490.

Romer P. M. Increasing returns and long-run growth // Journal of political economy. 1986. Vol. 94(5). P. 1002–1037.

Shearmur R. Are cities the font of innovation? A critical review of the literature on cities and innovation // Cities. 2012. Vol. 29. P. 9–18.

Shi K., Yang Q., Fang G., Yu B., Chen Z., Yang C., Wu J. Evaluating spatiotemporal patterns of urban electricity consumption within different spatial boundaries: A case study of Chongqing, China // Energy. 2019. Vol. 167. P. 641–653.

Sibiryaev A. Comparative analysis of foreign and domestic experience of creation of science cities [In Russian] // Vestnik Universiteta. 2015. Vol. 6(1). P. 157–161.

Solow R. Contribution to the theory of economic growth // Quarterly Journal of Economics. 1956. Vol. 70. P. 65–94.

Tyurchev K. Management of innovative systems: From national to local level [In Russian] // Public administration issues. 2021. Vol. 4. P. 185–206.

Van Winden W. Urban governance in the knowledge-based economy: Challenges for different city types // Innovation. 2008. Vol. 10. P. 197–210.

Wong C., Ng B., Azisan S., Hasbullah M. Knowledge structures of city innovation systems: Singapore and Hong Kong // Journal of Urban Technology. 2018. Vol. 25(1). P. 47–73.