Journal of Management & Technogy
e-ISSN: 2177-6652

ASSESSING THE INFLUENCE OF FACTORS ON THE DEVELOPMENT OF DIGITAL INFRASTRUCTURE IN RUSSIA

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Abstract

The study aims to determine the influence of several factors on the development of digital infrastructure in Russia. Based on the analysis of scientific literature, it is determined that the core of digital sovereignty is digital infrastructure. It is clarified that the digital infrastructure of the state is understood as a complex of technologies and systems that ensure the functioning and development of the digital economy. The authors have identified the key elements necessary for the functioning of the digital economy. The article also presents a system of resulting indicators and factors for the development of digital infrastructure in Russia. Thus, the greatest impact on digital infrastructure elements is exerted by the innovation activity and technological autonomy of the state and investment activity in the field of informatization and communications. The study results allow government agencies to formulate a digital transformation strategy with due regard to the key indicators reflected in the article that have a high degree of influence on the development of digital infrastructure components.

Keywords: digital infrastructure, digital sovereignty, factor, influence, assessment, state**.**

Editor Científico: José Edson Lara
Organização Comitê Científico
Double Blind Review pelo SEER/OJS
Recebido em 10.05.2023
Aprovado em 13.09.2023

INTRODUCTION

Due to the global trend of digital transformation of all spheres and sectors of the economy, countries are paying special attention to the development of digital technologies and services and ensuring digital security as an important component of national security. An institutional environment for the development of the digital economy and technologies has been created in Russia. This is confirmed by the development and adoption of a large number of regulatory legal documents in this area. The most important and backbone documents are the National Security Strategy of the Russian Federation, Scientific and Technological Development of the Russian Federation, National Development Goals of the Russian Federation until 2030, the "Digital Economy of the Russian Federation" National Program, and the "National Technology Initiative" Program. For the effective implementation of these and other digital transformation programs, development institutions at the federal and regional levels of government are being established.

The digital transformation of the Russian economy strongly depends on the development of digital infrastructure in a particular industry or territory. Currently, there is an uneven development of digital infrastructure in Russia. This differentiation is especially evident between urban and rural areas. The higher the urbanization of a territory, the higher the degree of its digitalization. The presence of digital infrastructure in large scientific, technological, and economic centers affects the socio-economic situation of the peripheral and remote territories, thereby they do not contribute to strengthening the digital sovereignty of the state.

Thus, disproportions in the implementation and use of digital technologies and services in certain regions of Russia necessitate the study of factors in the development of digital infrastructure as an integral part of the digital sovereignty of the state.

When studying the level of digitalization, an actor approach was used. All actors were divided into three groups: the population and organizations as the main consumers of digital infrastructure and the state as an institution for its creation and development.

Digital infrastructure is presented as a new paradigm of economic theory at the current stage of development of the state and society. However, the scientific community has not formed a unified approach to its definition. Many scholars consider digital infrastructure a system that provides the population, organizations, and government agencies with broadband access to the Internet. To determine the qualitative and quantitative characteristics of digital infrastructure, they study indicators of mobile and fixed communications, the use of digital

technologies, and Internet accessibility in both urban and rural areas (Ndubuisi et al. 2021; Li et al. 2022; Goldbeck & Lindlacher, 2021).

N.N. Krupina (2023) defines digital infrastructure as an indicator of the level of the digital economy and provides a broad concept that includes information infrastructure and security, staffing, and legislative regulation.

For some scholars, the concepts of digital and information infrastructure are identical. When highlighting digital infrastructure as a special case of information infrastructure, they justify the equivalence of concepts by the fact that information infrastructure at the present stage of development is based on digital technologies (Gribanov et al. 2020).

We understand digital infrastructure as a complex of technologies and systems that ensure the functioning and development of the digital economy. It includes technologies and systems for creating, collecting, storing, transmitting, and processing data; digital economy personnel, digital platforms, services, software, systems, devices that provide access to broadband and satellite Internet, and other elements necessary for the functioning of the digital economy.

Digital infrastructure is an integral part of a country's digital sovereignty. It ensures the functioning and development of the state's information space. The formation of digital infrastructure is influenced by many different factors. They can be divided into several groups.

The first group consists of economic factors. A.Yu. Samokhvalov (2019) emphasizes the lack of financial resources, especially for small- and medium-sized businesses and the development of digital infrastructure. The author refers to the example of e-commerce and the fact that SMEs lack digital competences. N.V. Mityaeva and O.V. Zavodilo (2019) mention the lack of funding for digital transformation. This is reflected in the complexity of integrating a large number of digital solutions and updating them. As exemplified by PAO "Rostelecom", scholars surveyed its employees and showed that the main problems in the use of information and communication technologies in the corporation included the lack of funding (63.7% of responses) and insufficient professional qualification (30.4%). In the course of their research, Latin American economists concluded that government subsidies in the field of research and development stimulated business spending in this area, which promoted the innovative development of the economy alongside tax incentives and government technology policies (Afcha&Lopez, 2014). Chinese scholars dwell on the targeted financing of digital infrastructure (Song&Zhou, 2023). D. Webber (2022) et al. confirmed the importance of digital investments.

The second group of factors is social. E.V. Pisarev et al. consider the difficulties of digital transformation at the regional level and show the lack of qualified personnel. This problem is

especially acute for the most remote regions of the country. In addition, scholars claim the insufficient effectiveness of educational programs that do not focus on acquiring skills in the digital environment and weak innovation activity in the regions as exemplified by differences between Moscow and peripheral regions (Pisarev et al. 2022). Other scholars highlight the medium- and long-term effects of education, including the launch of new educational programs in the field of information and communication technologies. On the contrary, they warn about serious damage from untimely and poor-quality innovations in education (Klimenko et al. 2020). Social factors also include the conservatism of corporate culture, staff shortages, and unpreparedness for sudden digital changes among IT department employees.

C.C. Hang and J. Chen (2021) mention the dependence of developing countries on transnational corporations and their investments when it comes to disruptive innovation. In this process, local companies are newcomers that lack investment, experience, and technology.

A.I. Lukashin (2021) pays attention to ongoing urbanization processes as one of the main reasons for underinvestment in digital infrastructure in rural areas. Lukashin dwells on the declining share of young people among the rural population (the most active users of IT) and the importance of state activities in the digitalization of rural areas.

According to N.N. Krupina (2023), the problem of infrastructural inequality between urban and rural areas will be relevant for large countries for many decades. Krupina emphasizes that it is impossible for settlements remote from growth points to build, modernize, and maintain infrastructure without government assistance, much less integrate into the national digital space.

E.G. Popkova (2023) indicates the significance of the coronavirus pandemic and sanctions on Russia due to the aggravation of the geopolitical situation as factors stimulating Russia's transition to Industry 4.0. As examples of digital transformation, Popkova cites the development of distance digital learning at all levels of the education system, an increase in government funding for the IT sector, and the development of a legal framework in information and communication technologies. A Swedish political scientist draws attention to the fact that sanctions against Russian banks and the SWIFT ban made not only Russia but also China, India, and other countries develop the necessary infrastructure and software for conducting international transactions (Nölke, 2022). Among negative external factors in the development of digital infrastructure, the researcher cites the EU and its dependence on US correspondent banks and technological equipment for financial services (servers or semiconductors). P. Roffia and L. Mola (2022) point to the COVID-19 pandemic as a factor in the digitalization of companies, which entailed the need for information infrastructure. As exemplified by the

implementation of ERP systems by small- and medium-sized businesses, scholars show the lack of investment, lack of qualified personnel, and the difficulty for SMEs to implement complex information and communication technologies (Federal State Statistics Service, n.d.).

As a result of the comparative analysis of scientific research, we put forward a hypothesis that the development of digital infrastructure is influenced by a set of related factors.

METHODS AND MATERIALS

To assess the influence of the above-mentioned factors, we propose our own methodological approach.

At the first stage of the study, we compared existing studies to determine those factors influencing the development of digital infrastructure and the main actors.

At the second stage, we formed a system of indicators to assess the development of digital infrastructure and display the factors influencing it (Table 1).

Table 1. System of resulting indicators and factors of digital infrastructure development in Russia

Factors		
Directions	Indicators	Code
Innovation activity of the state	Developed advanced production technologies, units	F1
	Share of innovative goods, works, and services in the total volume of goods, works, and services, %	F2
Technological autonomy of the state	Share of high-tech goods in total imports, %	F3
	Import of technologies and technical services (number of agreements), units	F4
Financing of research and development	Domestic research and development costs, % of gross domestic product	F5
State investment activity in the field of information and communications	Volume of investments in fixed capital in the field of information and communications, million rubles	F6
	Volume of investments in fixed assets aimed at purchasing information, computer and telecommunications equipment, million rubles	F7
Economic activity of the state in the field of information and communications	Share of activities in the field of information and communications in the gross domestic product, %	F8
State personnel potential in the field of information and communications	Number of graduates of Bachelor's programs in ICT areas, people	F9
	Number of graduates of Specialist's programs in ICT areas, people	F10
	Number of graduates of Master's programs in ICT areas, people	F11
Result		
Actors	Indicators	Code
Population as a consumer of digital infrastructure	Share of households with broadband Internet access in the total number of households, %	R1
	Number of connected mobile communication devices per 1,000 population, units	R2
	Number of active subscribers of fixed broadband Internet access per 100 population, units	R3
	Number of active mobile broadband Internet subscribers per 100 population, units	R4

	Share of the population using the Internet to order goods and services in the total population aged 15-72 years, %	R5
	Share of Internet users in the total population, %	R6
Organizations as consumers of digital infrastructure	Use of broadband Internet access, % of the total number of surveyed organizations	R7
	Availability of PCs, % of the total number of surveyed organizations	R8
	Availability of servers, % of the total number of surveyed organizations	R9
	Availability of local computing servers, % of the total number of surveyed organizations	R10
	Availability of cloud services, % of the total number of surveyed organizations	R11
	Availability of websites, % of the total number of organizations surveyed	R12
	Use of electronic document management systems, % of the total number of surveyed organizations	R13
	Electronic data exchange between internal and external information systems by document exchange formats, % of the total number of surveyed organizations	R14
	Number of PCs per 100 employees, including those with Internet access, units	R15
State as the creator of digital infrastructure (public authorities)	Level of digitalization of the local telephone network in urban areas, %	R16
	Level of digitalization of the local telephone network in rural areas, %	R17
	Share of citizens using the mechanism for receiving state and municipal services in electronic form, %	R18

Source: compiled by authors.

At the next stage, we formed a database based on the indicators substantiated.

At the fourth stage, we conducted a regression analysis to evaluate the influence of the factors identified on individual elements of digital infrastructure. Close connections were normalized by the R^2 coefficient of determination. When checking, the p-value did not exceed 0.05, and F-statistics did not exceed the table values. Thus, the reliability of results was at least 95%. The criterion for a relationship between an indicator and a factor is the numerical value of the coefficient of determination above 0.3 using the Chaddock scale.

At the final stage, we interpreted the results obtained.

The main sources of information are databases of scientific publications and data from the state statistics service, the Ministry of Science and Higher Education of the Russian Federation, and the National Research University Higher School of Economics.

RESULTS AND DISCUSSION

Based on the results of regression analysis (Table 2), we can draw the following conclusions.

Table 2. The influence of factors on the development of digital infrastructure in Russia (regression analysis results)

Influencing factor	Actors	Population						Organizations									State		
	Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18
Innovation activity of the state	F1	0.89	0.77	0.66	-	-	0.77	0.40	0.83	0.49	0.75	-	-	No data	0.65	-	0.64	0.75	-
	F2	0.70	0.75	0.93	0.95	0.86	0.92	-	0.30	-	0.30	0.91	-	0.77	-	0.72	0.93	0.90	0.88
Technological autonomy of the state	F3	0.80	0.56	-	-	-	-	-	0.57	-	0.67	-	-	0.35	_	-	0.81	0.77	-
	F4	0.89	0.82	0.96	0.98	-	0.98	-	0.44	-	0.47	0.84	-	0.88	-	0.87	0.99	0.97	-
Financing of research and development	F5	-	-	-	-	-	-	-	-	-	-	-	0.60	0.87	0.39	-	-	-	0.66
Investment activity of the state in the field of information and communications	F6	0.80	0.84	0.87	0.98	0.86	0.94	-	0.52	-	0.50	0.74	-	0.80	-	0.89	0.91	0.94	0.79
	F7	0.78	0.78	0.90	0.97	0.93	0.94	-	0.57	-	0.55	0.72	_	0.75	-	0.87	0.92	0.93	0.79
Economic activity of the state in the field of information and communications	F8	0.55	0.51	-	-	-	-	0.76	0.83	0.49	0.75	0.76	-	No data	0.65	-	0.64	0.75	-
State personnel potential in the field of information and communications	F9	-	-	-	-	-	-	-	-	0.30	-	-	0.32	-	-	-	-	-	-
	F10	0.30	-	-	-	-	-	-	-	-	-	0.32	-	0.48	-	-	0.32	0.33	0.41
	F11	0.43	-	0.76	0.58	-	0.63	-	-	-	-	0.81	0.43	0.70	-	0.31	0.70	0.62	-
			– weak and medium connection									– close and very close connection							

Source: compiled by authors

The innovation activity of the state and its technological independence are closely interconnected and affect the development of digital infrastructure in Russia. The level of digital infrastructure among the population and the state is particularly influenced by the share of innovative products, works, and services in their total volume and their imports. The number of advanced technologies developed and the share of high-tech goods in imports have a major impact on broadband access to the Internet and the digitalization of the local telephone network in rural areas.

A decline in the share of innovative products, works, and services in the total volume of products shipped, works performed, and services offered from 2015 to 2021 was closely connected with the use of cloud services by organizations. Since these services were mainly of foreign origin, a drop in the innovativeness of shipped goods (works or services) stimulated organizations to switch to cloud solutions, which also affected the access of employees to PCs.

The volume of internal costs had a larger impact on research and development expressed in the use of electronic document management systems, data exchange between internal and external information systems, and websites of Russian organizations.

Investment activity in the field of information and communications influences the above-mentioned aspects of digital infrastructure created by the state and used by the population.

Among organizations, a high correlation is observed only between the volume of investments and the use of cloud-based services and electronic document management systems. The insignificant impact of investments in organizations is due to the fact that management directs investments to satisfy basic needs in the field of information and communications: the purchase of PCs, Internet access, and disk space in the form of cloud-based services.

A high correlation is observed among the share of informatization activities in the gross domestic product, the corporate use of PCs, local computing and cloud-based services, broadband access, and the digitalization of the local telephone network in rural areas. This fact reflects the state's strategic guidelines for the formation of digital sovereignty.

Regarding the impact of human resources on the development of digital infrastructure, there is an increase in influence depending on the level of their education. Thus, the number of graduates of Bachelor's and Specialist's programs in information and communication technologies does not have a significant relationship with the indicators. This is justified by the fact that the share of those employed according to their Bachelor's degree does not exceed 54-70%. The number of graduates of Master's programs in information and communication technologies has a medium and very close relationship with the share of the population using fixed broadband access to the Internet and with the share of organizations using cloud-based services or electronic document management. Graduates with a Master's degree usually have a higher standard of living and are employed, which can be reflected in more active use of effective information and communication technologies. Consequently, postgraduate students with a higher level of education have a positive impact on the development of digital infrastructure directly through their employment in IT companies, research centers, and other organizations or indirectly by increasing the demand for digital infrastructure.

CONCLUSIONS

The results of the study confirmed our hypothesis. The specifics of the applied approach are associated with our attempt to assess the impact of related factors on the development of digital infrastructure as an element of the country's digital sovereignty, depending on the actors.

Different factors have different influences. The major impact on the development of infrastructure among the population and the state is the innovation activity and technological autonomy of the country and its investment activity in the field of information and communications.

The development of digital infrastructure elements among organizations is also influenced by the financing of research and development, economic activity, and the human resource potential of the state in the field of digitalization and communications.

The most susceptible to the influence of various factors are such aspects of digital infrastructure as broadband access to the Internet and mobile communications and the availability and ability of organizations to use personal computers, cloud services, and electronic document management systems. From the position of the state, it is necessary to ensure the digitalization of the local telephone network in both urban and rural areas, which is associated with general digitalization trends in the country.

Our results can be considered when forming and adjusting documents at the federal level of government aimed at developing digital infrastructure and strengthening digital sovereignty.

ACKNOWLEDGMENTS

The research was conducted with the financial support of the project FSRU-2023-0017 as part of the state assignment for fundamental scientific research on the topic “Challenges and prospects for the development of digital sovereignty of the Russian Federation”, 2023.

REFERENCES

Afcha, S., López, G.L. (2014). Public funding of R&D and its effect on the composition of business R&D expenditure. BRQ Business Research Quarterly, 17(1), 22-30.

Federal State Statistics Service. (n.d.). Retrieved from: https://rosstat.gov.ru (Accessed on October 15, 2023).

Goldbeck, M., Lindlacher, V. (2021). Digital Infrastructure and Local Economic Growth: Early Internet in Sub-Saharan Africa. Job market paper.

Gribanov, Yu.I., Rudenko, M.N., Alenina, K.A. (2020). Sovremennye podkhody k formirovaniyu tsifrovoi infrastruktury [Modern approaches to the formation of digital infrastructure]. Upravlencheskoe konsultirovanie, 8(140), 88-98. https://doi.org/10.22394/1726-1139-2020-8-88-98.

Hang, C.C., Chen, J. (2021). Innovation management research in the context of developing countries: Analyzing the disruptive innovation framework. International Journal of Innovation Studies, 5(4), 145-147.

Klimenko, E.Yu., Neizvestnyi, S.I., Sheshukov, M.A. (2020). Cotsialno-metodicheskie problemy formirovaniya kompetentsii spetsialistov upravleniya avtomatizirovannymi sistemami tsifrovoi ekonomiki [Social and methodological problems of developing the competences of specialists in managing automated systems of the digital economy]. Upravlenie bolshimi sistemami, 83, 53-74.

Krupina, N.N. (2023). K voprosu o tsifrovoi infrastrukture selskikh territorii [On digital infrastructure in rural areas]. Regionalnaya ekonomika i upravlenie: elektronnyi nauchnyi zhurnal, 2(74). Electronic resource. URL: https://www.elibrary.ru/download/elibrary_54105293_23004739.pdf (Accessed on October 12, 2023).

Li, X., Li, J., Yuan, C., Guo, S., Wang, Z. (2022). Digital Infrastructure. In: Development Practice of Digital Business Environment in China. Applied Economics and Policy Studies. Springer, Singapore. https://doi.org/10.1007/978-981-16-8527-9_3.

Lukashin, N.A. (2021). Informatsionnye tekhnologii i infrastruktura selskikh territorii [Information technology and rural infrastructure]. Kreativnaya ekonomika, 6, 2603-2614. https://doi.org/10.18334/ce.15.6.112193.

Mityaeva, N.V., Zavodilo, O.V. (2019). Barery tsifrovoi transformatsii i puti ikh preodoleniya [Barriers to digital transformation and ways to overcome them]. Promyshlennost: ekonomika, upravlenie, tekhnologii, 3(77), 20-24.

Ndubuisi, G., Otioma, Ch., Tetteh, G.K. (2021). Digital infrastructure and employment in services: Evidence from Sub-Saharan African countries. Telecommunications Policy, 45(8). https://doi.org/10.1016/j.telpol.2021.102153.

Nölke, A. (2022). The weaponization of global payment infrastructures: A strategic dilemma. SAFE White Paper, 89.

Pisarev, I.V., Byvshev, V.I., Panteleeva, I.A., Parfenteva, K.V. (2022). Issledovanie gotovnosti regionov Rossii k tsifrovoi transformatsii [Studying the readiness of Russian regions for digital transformation]. P-Economy, 2, 22-37. https://doi.org/10.18721/JE.15202.

Popkova, E.G., Bogoviz, A.V., Ekimova, K.V., Segi, B.S. (2023). Will Russia Become a Blueprint for Emerging Nations' High-Tech Reforms? Evidence from a 26-Countries dataset. International Journal of Innovation Studies.

Roffia, P., Mola, L. (2022). Is COVID-19 enough? Which underestimated conditions characterize the adoption of complex information infrastructures in small- and medium-sized enterprises. Journal of Business Research, 144, 1249-1255.

Samokhvalov, A.Yu. (2022). Razvitie infrastruktury elektronnoi torgovli v Rossii na sovremennom etape [Development of e-commerce infrastructure in Russia at the present stage]. Kant, 4(45), 91-95.

Song, M.X., Zhou, Y.Y. (2023). How Does the Smart City Policy Influence Digital Infrastructure? Spatial Evidence from China. Land, 12, 1381. https://doi.org/10.3390/land12071381.

Webber, D., Hughes, E., Pacheco, G., Parry, G. (2022). Investment in digital infrastructure: why and for whom? Region, 9(1), 147-163. https://doi.org/10.18335/region.v9i1.415.