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Analysis of the use of digital technologies in organisations in the regions of Russia

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Subject. The digitalisation of the economy is not only shaping a new business environment, it is also setting the direction for the development of various spheres of society. Organisations are seeking to integrate digital technologies into their business processes to boost their efficiency and to build business relationships and connections. The adoption of digital technologies introduces significant socio-economic changes. Among other things, it increases the level of competition, forcing companies to be more dynamic and agile in order to maintain their competitive advantage. However, because of the uneven implementation of digital technologies in the regions, it is not possible to develop uniform recommendations for the promotion of digitalisation. Therefore, it is necessary to identify regions with similar digitalisation trends in order to determine their weaknesses and strengths, and to develop relevant digital development strategies.
Objectives. The aim of the study was to identify clusters (typological groups) of the regions of the Russian Federation according to the characteristics of the use of digital technology by the organisations in these regions. We also wanted to study the dynamics of the clusters from 2015 to 2020.
Methods. The study was based on data from Rosstat on the use of digital technologies (ICT) by organisations in the regions of Russia for 2015, 2018, and 2020. In the research, clustering and comparative analysis were used.
Conclusions. As a result of the study, we obtained typological groups of regions with similar characteristics of ICT development and use by organisations in the regions of the Russian Federation over three periods. We analysed trends in clusters and their composition. The study will make it possible to identify advantages and bottlenecks in the use of ICT by regional enterprises. It can be used to improve the region's development strategy in general and to develop regional innovation activities and digital maturity.

Keywords: regions, digitalisation, information and communication technologies, clusters, innovation.

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Introduction

Nowadays, the use of digital technologies is one of the main factors of innovative development and competitive performance. Opportunities such as new forms of high-speed communication to create and to distribute innovations, access to large databases, and data mining are important for the intensification of innovation activities. Both globally and in Russia, the digital sector is developing at great speed. Over the past decade, Russian regions have made certain progress in the development of digital technologies, both in organisations and enterprises and at the household level. At the same time, digitalisation, defined as "the application or greater use of digital technologies by an organisation, an industry, or a country" (OECD, 2018), means that not only new opportunities have arisen, but also new risks. It is important to note that the existing differences in the development levels between the regions, both in European countries (Haefner & Sternberg, 2020) and in Russia (Zubarevich, 2021; Makarov et al., 2016), affect the processes of digitalisation. These processes are not uniform: on the one hand, the economic development of the regions influences the adoption of information and communication technologies (ICT); on the other hand, the level of development of the digital economy in a region has an effect on its innovative development opportunities.

Starting from 2002, ROSSTAT started to take into account individual indicators of ICT use in the context of regional policy. In 2005, digitalisation indicators were allocated to a separate group "Communications, Telecommunications, and Information Technologies". From 2006, a separate section "Information and Communication Technologies" was introduced[1]. Moreover, data on digitalisation are available in the subsection "Digital Technology" of the section "Science, Innovation, and Technologies" and in the section "Information Society".

In 2017, the programme "Digital Economy of the Russian Federation" was adopted (Executive Order of the Government of the Russian Federation No 1632-r of July 28, 2017). The programme aims "to create conditions for the development of a knowledge society in the Russian Federation, to improve the well-being and standards of living of the citizens of our country by increasing the accessibility and quality of goods and services produced by the digital economy using modern digital technologies, increasing awareness and digital literacy, improving the accessibility and quality of public services for citizens, as well as security both inside and outside the country" (Kuznetsov, 2019).

In 2021, Prime Minister Mikhail Mishustin approved the methodology for calculating the indicators of "digital maturity" of the regions. It allowed the Ministry of Digital Development, Communications, and Mass Media of the Russian Federation to provide a digital maturity rating of the regions. By the end of 2021, all regions have adopted digital transformation strategies in accordance with the methodology and template developed by the government commission on digital development and the use of information technology to improve the quality of life and business environment.

In recent years, a great number of scientific papers have been devoted to assessing the digitalisation of regions. Let us focus on some of them.

In his paper (Sadyrtdinov, 2020), R. R. Sadyrtdinov ranked the regions according to the composite digitalisation index, averaged over 2013–2018. The researcher chose four indicators, which can be understood as digital mobility, digital equality, digital economy, and digital interaction. The research makes it possible to understand the region's position over the considered period, but the dynamics of changes in the indicators cannot be studied.

Tatarnikova, Rasskazova, and Pravdina (Tatarnikova et al., 2020) discuss the importance of digitalisation rating of the regions not only for assessing the achievement of target indicators, but also for determining the effectiveness of public policies and support measures. In addition, the authors analyse in detail the urban digitalisation index "IQ of Cities" developed by the Ministry of Construction, Housing, and Utilities of Russia for cities with a population of over one million, large cities, administrative centres, and pilot cities of

[1] Federal State Statistics Service. URL: https://rosstat.gov.ru/

the "Smart City" project in 2018. The authors also presented a ranking of ICT expenditures in 2018–2019. The leaders were Moscow, St. Petersburg, and the Moscow region, whose spending on digitalisation far exceeded that of all other regions.

The study by Safiullin, Ablukaeva, and Elshin (Safiullin et al., 2019) proposes a methodological approach and algorithm for assessing the effectiveness of digitalisation of regional economic systems. The composite index for 2015–2017 is calculated as the "weighted" sum of sub-indices in five areas of regional development: regulatory control, human resources for the digital economy, development of research competencies and technological advances, information infrastructure, and information security. Based on the results, the regions were divided into six groups, allowing for the design of special measures of state regulation to reduce the differentiation in the levels of digital development in the regions and to assess the prospects for the development of certain regions.

Pisarev, Byvshev et al. (Pisarev et al., 2022) proposed to take the information society development index as a composite indicator of a region's digital development. It is calculated as a weighted sum of the "Information Society Development Factors" sub-index (10 indicators) and the "Use of Information and Communication Technologies by Individuals and Organisations" sub-index (34 indicators). The rankings of regions based on the data for 2012 and 2019 were compared.

In a number of articles, specific groups of regions were analysed, e.g. regions of the North of Russia (Egorov et al., 2022), leaders and outsiders by certain digitalisation indicators (Minakov & Yevrayev, 2020; Fatkhullin, 2020), or regions of the Siberian Federal District (Dudin et al., 2021). Some studies also consider the impact of digitalisation on the formation of regional industrial clusters and analyse these clusters. Konkina, Shemyakin, and Babkin considered the use of modern IT-technologies in the regional industrial cluster in their research (Konkina et al., 2019).

Chernysheva and Kalygina (Chernysheva & Kalygina, 2019) analysed the dynamics of the digitalisation index in the regions of Russia for 2014–2018. The authors concluded that the highest growth of the digitalisation index was observed in the regions with the highest level of innovation activity. Meanwhile, Nikolaev, Makhotaeva, and Gusarova point out that "the low level of investment and innovation activity of enterprises in the regions, as well as the insufficient use of digital business models contributes to the lack of a meaningful relationship between the level of digitalisation of regional enterprises and the dynamics of its socio-economic development" (Nikolaev et al., 2020).

Obviously, digitalisation has both positive and negative effects. These issues and risk mitigation methods for digitalisation of regions were considered by Gorodkova and Petrova (Gorodkova & Petrova, 2021).

One of the key concerns of digitalisation is the digital inequality of the regions. "The level of digitalisation in the Russian regions varies greatly. The research team from the Moscow School of Management SKOLKOVO came to this conclusion by examining the availability and accessibility of digital services in key areas of everyday life in more than ninety cities: transport, finance, trade, social sphere, media, and the public sector"[2]. "With a wide digital life development gap, a city risks losing its most innovative, dynamic, and mobile residents." noted V. Korovkin[3]. Therefore, it is important to understand the similarities and differences between the regions in terms of the progress of digitalisation. This will help develop digital supply and demand, build skills and competencies in the effective use of digital platforms and systems, and improve the quality of human capital and the creative innovation environment[4].

In our works published in 2021 (Maslova & Schepina, 2021; Schepina & Maslova, 2022), we assessed the level of regional innovation in relation to digitalisation in 2015 and 2018. These works revealed the need for a more in-depth analysis of the uneven digital development of the regions, which provided the basis for further research.

In this paper, we identified clusters of regions with similar characteristics of ICT use by local organisations (as it is the digitalisation of organisations that has a greater impact on

[2] Korovkin V. Digital Life of Russian Regions. URL: https://www.skolkovo.ru/researches/digital-life-of-russian-cities/

[3] Ebid.

[4] Ebid.

innovation activity in the region) and traced the dynamics of the clusters' composition from 2015 to 2020.

Methodology

The analysis of the digitalisation of regional organisations and the identification of groups of regions similar in the level and structure of the digital potential of organisations was carried out in several stages.

At the first stage, we prepared an Excel database from the statistical data of the Federal State Statistics Service (ROSSTAT), subsection "Information and Communication Technologies" for 2015, 2018, and 2020 of the section "Regions of Russia. Socio-economic indicators".

The analysis was based on the following indicators (all indicators related to the digitalisation of organisations in the region were selected) for 80 regions of the Russian Federation:

x_1 – the use of information and communication technologies in organisations (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation),

x_2 – the use of the Internet in organisations (as a percentage of the total number of organisations surveyed),

x_3 – organisations that have a website (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation),

x_4 – the number of personal computers per 100 employees (pcs),

x_5 – the use of special software in organisations (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation),

x_6 – expenditures on the introduction and use of digital technologies (million roubles),

x_7 – the use of electronic document management systems in organisations (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation).

Moscow was excluded from the analysis, as the city exceeds the other regions in a number of indicators, and its expenditures for the introduction and use of digital technologies are an order of magnitude higher. So, it would form a separate cluster.

It is important to note that indicator x_1 has two components, in particular, the use of personal computers; x_{11} and the use of servers; x_{12} (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation). Therefore, the values of x_1 were taken as the arithmetic mean of the respective indicators.

The resulting data for each year were normalised using formula (1):

$$x_i^{rn} = \frac{x_i^r - x_{i\,min}}{x_{i\,max} - x_{i\,min}}; \quad (1)$$

where i – is the indicator number, r – is the region number; x_i^{rn} – is the normalised value of the i-th indicator of the r-th region; x_i^r – is the value of the i-th indicator of the r-th region; $x_{i\,min}$ – is the maximum value of the indicator; $x_{i\,min}$ – is the minimum value of the indicator.

In the second stage, a cluster analysis was carried out for each year. Based on the hierarchical clustering, an appropriate number of clusters was determined. Then, a K-means classification was carried out using the Statistica software package. The analysis identified regions with similar digitalisation rates.

In the third stage, the average values of the indicators per cluster and the composition of clusters were analysed for each year.

In the fourth stage, we carried out a comparative analysis of the average values and composition of clusters over the years and analysed the dynamics of digitisation indicators for individual regions.

Results and discussion

When analysing the data for 2015, 5 clusters were identified based on the above indicators ($x_1 - x_7$). All indicators were statistically significant at the 0.1 % level ($p < 0.001$). Further, we similarly clustered the data for 2018, where the significance level was also at 0.1 % ($p < 0.001$). For 2020, all indicators were statistically significant at 0.1 % ($p < 0.001$), except for the indicator 'expenditures on the introduction and use of digital technologies' with a significance level of 5 %. The results of clustering and the average values of the indicators by clusters are presented in Table 1 and in Figures 1, 2, and 3.

Table 1

Cluster averages in 2015, 2018, and 2020

Indicators for digitalisation of organisations (normalised average values)	Year	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
The use of information and communication technologies in organisations (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation)	2015	0.959	0.762	0.723	0.472	0.234
	2018	0.917	0.777	0.728	0.603	0.329
	2020	0.600	0.825	0.673	0.167	0.270
The use of the Internet in organisations (as a percentage of the total number of organisations surveyed)	2015	0.772	0.748	0.534	0.507	0.237
	2018	0.818	0.784	0.673	0.537	0.380
	2020	0.775	0.808	0.696	0.665	0.408
Organisations that have a website (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation)	2015	0.695	0.615	0.400	0.271	0.122
	2018	0.941	0.662	0.517	0.358	0.391
	2020	0.744	0.749	0.524	0.495	0.285
The number of personal computers per 100 employees (pcs)	2015	0.654	0.403	0.620	0.376	0.438
	2018	0.606	0.547	0.597	0.466	0.131
	2020	0.690	0.261	0.370	0.315	0.456
The use of special software in organisations (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation)	2015	0.853	0.853	0.781	0.653	0.273
	2018	0.912	0.934	0.828	0.789	0.211
	2020	0.783	0.800	0.666	0.635	0.426
Expenditures on the introduction and use of digital technologies (million roubles)	2015	0.907	0.093	0.049	0.043	0.027
	2018	0.743	0.050	0.060	0.032	0.005
	2020	0.193	0.127	0.085	0.084	0.027
The use of electronic document management systems in organisations (as a percentage of the total number of organisations surveyed in the respective region of the Russian Federation)	2015	0.681	0.779	0.641	0.564	0.335
	2018	0.787	0.812	0.604	0.637	0.132
	2020	0.802	0.828	0.641	0.617	0.405
Total	2015	5.522	4.253	3.747	2.887	1.667
	2018	5.725	4.566	4.008	3.422	1.579
	2020	4.588	4.398	3.655	2.976	2.278

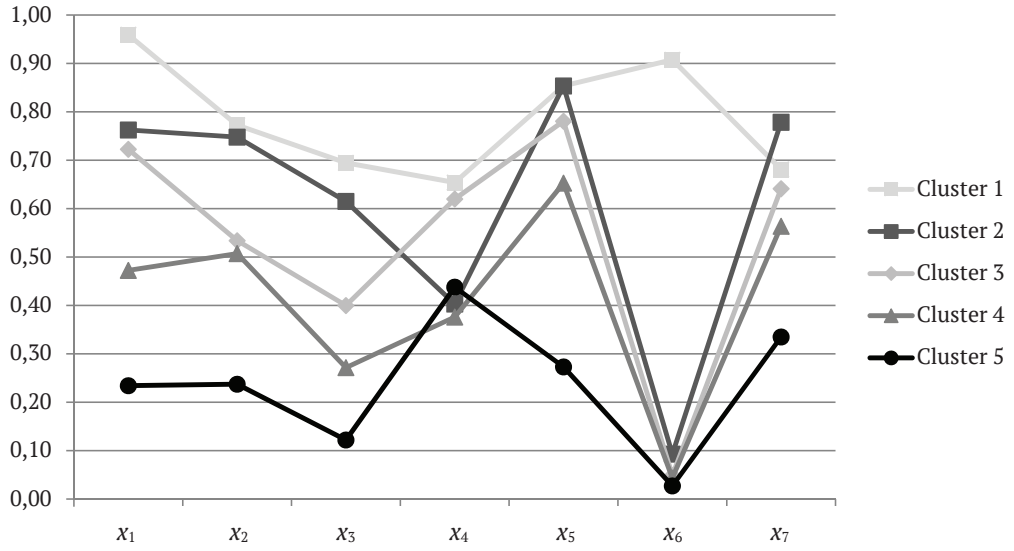


Fig. 1. Average values of indicators per cluster, 2015

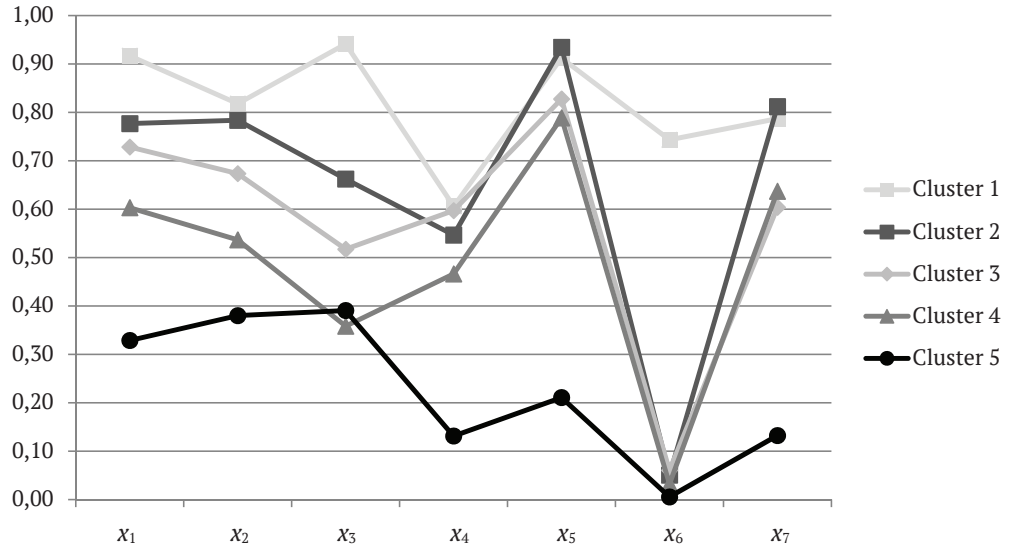


Fig. 2. Average values of indicators per cluster, 2018

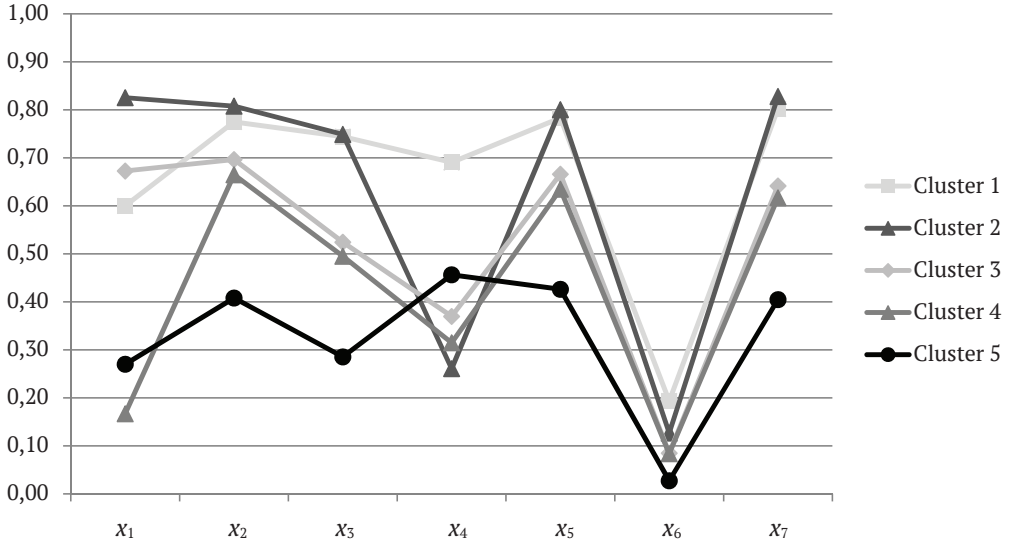


Fig. 3. Average values of indicators per cluster, 2020

The dynamics of average values and the composition of each cluster are presented in Figures 4–8.

Analysing the clustering results (Fig. 1–3), it should be noted that the clusters are numbered according to the decreasing sum of the average values of the indicators. So, the first cluster corresponds to the regions with the highest level of digitalisation, and the fifth cluster shows the most lagging behind regions.

However, it is important to note that cluster 1, which contains the leading regions, is behind clusters 2 and 3 by the indicator "The use of information and communication technologies in organisations" in 2020. On the other hand, the lagging regions, which belong to cluster 5, are ahead of the regions in cluster 4 by this indicator. We also observed a similar pattern for the indicator "The use of the Internet in organisations": in 2015 and 2018, the indicator values were clearly corresponding to the clustering, while in 2020 regions in cluster 1 lost first place to cluster 2. Clusters 1 and 2 have almost identical values for the indicator "Organisations that have a website".

Particular attention should be paid to the large gap in the values for the indicator x_6 "Expenditures on the introduction and use of digital technologies" between cluster 1 and other clusters in 2015 and 2018. The chart shows that digitalisation expenditures in St. Petersburg and the Tyumen Region in 2015 and in St. Petersburg and the Moscow Region in 2018 greatly exceed all other regions with comparable expenditures. By 2020, due to the expansion of the cluster 1 (9 regions), there was an overall decrease in the average value of the indicator x_6 across all clusters.

For 2018 and 2020, the regions can be divided into three groups according to the indicator x_7, "The use of electronic document management systems in organisations": clusters 1 and 2 as the leaders, clusters 3 and 4 as the medium, and cluster 5 as the outsiders.

In 2020, cluster 2 almost caught up with cluster 1. It even took the lead in terms of the indicators x_1 and x_2, but it was behind all other clusters in terms of x_4, "The number of personal computers per 100 employees". Then, we considered the dynamics of the average indicators for each cluster separately over three different time periods. Cluster 1 in 2015 and 2018 contained 2 regions. By 2020, there was an overall downward trend in almost all indicators compared to 2018 due to the expansion of the clusters. ICT expenditures have decreased particularly (x_6). However, there is a positive fact that the leading group expanded to 9 regions (Figure 4).

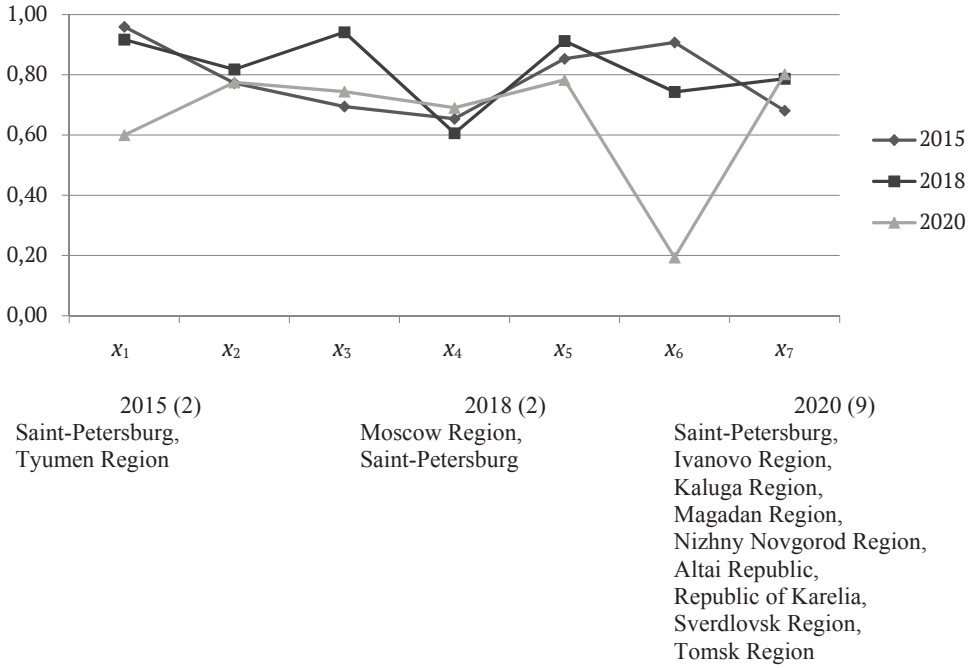
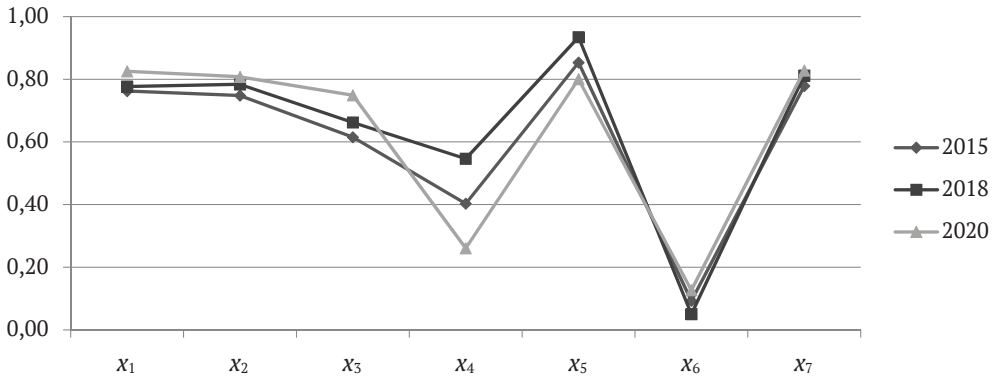


Fig. 4. Average values of indicators and composition of cluster 1

In cluster 2 (Figure 5), there is a small but steady increase in the average use of information and communication technologies (x_1), the Internet in organisations (x_2), and in the share of organisations that have a website (x_3). A significant reduction in the number of personal computers per 100 employees (x_4) is probably due to the fact that many companies adopted remote working or reduced their staff due to the pandemic. Personal computers of employees not owned by the organisation are not included in the statistics. Perhaps for the same reason, there was a slight drop in the average value of the indicator x_5 ("The use of special software in organisations"). There were almost no changes in the average values of the indicators x_6 and x_7. There were changes in the cluster composition: in 2015, it consisted of 21 regions, in 2018 it expanded to 29 regions, and in 2020 it decreased by two thirds (10 regions). On the one hand, there is an increase in the level of digitalisation of organisations: 6 regions (the Ivanovo, Kaluga, Nizhny Novgorod, and Sverdlovsk Regions,



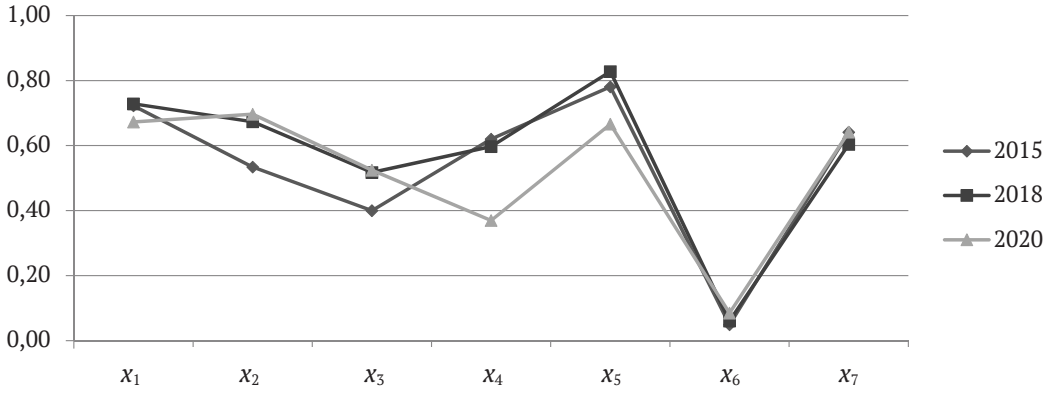
2015 (21)	2018 (29)	2020 (10)
Belgorod Region,	Astrakhan Region,	Belgorod Region,
Vladimir Region,	Belgorod Region,	Vladimir Region,
Leningrad Region,	Vladimir Region,	Voronezh Region,
Lipetsk Region,	Voronezh Region,	Leningrad Region,
Moscow Region,	Sevastopol,	Lipetsk Region,
Murmansk Region,	Ivanovo Region,	Moscow Region,
Nizhny Novgorod Region,	Kaluga Region,	Novgorod Region,
Orenburg Region,	Leningrad Region,	Smolensk Region,
Republic of Adygea,	Lipetsk Region,	Tambov Region,
Republic of Bashkortostan,	Nizhny Novgorod Region,	Chelyabinsk Region
Republic of Karelia,	Novgorod Region,	
Republic of Crimea,	Orenburg Region,	
Republic of Tatarstan,	Perm Territory,	
Republic of Khakassia,	Pskov Region,	
Sverdlovsk Region,	Altai Republic,	
Stavropol Territory,	Republic of Bashkortostan,	
Udmurt Republic,	Republic of Karelia,	
Khabarovsk Territory,	Republic of Tatarstan,	
Chelyabinsk Region,	Rostov Region,	
Chuvash Republic,	Ryazan Region,	
Yaroslavl Region	Sverdlovsk Region,	
	Smolensk Region,	
	Stavropol Territory,	
	Tambov Region,	
	Udmurt Republic,	
	Khabarovsk Territory,	
	Chelyabinsk Region,	
	Chuvash Republic,	
	Yaroslavl Region	

Fig. 5. Average values of indicators and composition of cluster 2

the Altai Republic and the Republic of Karelia) moved into leading cluster 1 in 2020. On the other hand, the composition of cluster 2 decreased by another 13 regions.

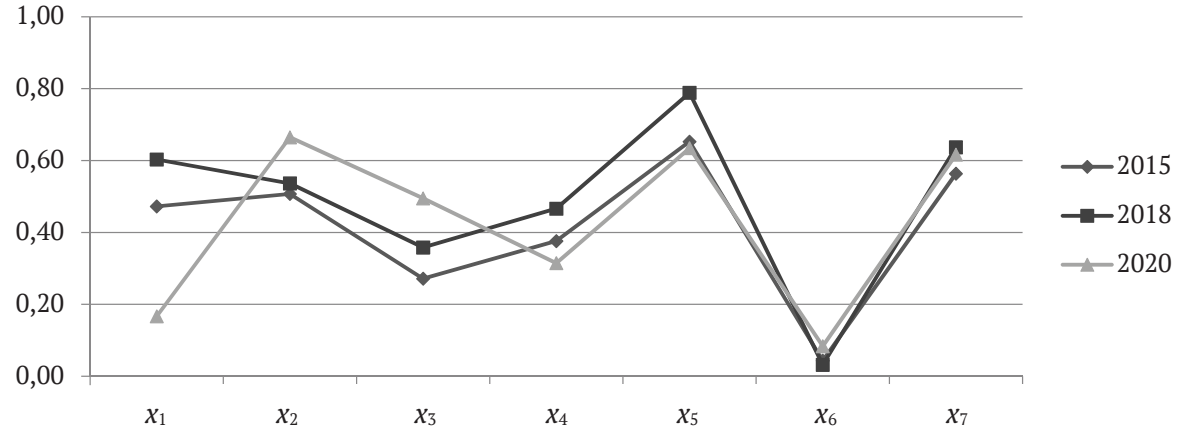
Cluster 3 (Figure 6) in 2018 showed an increase in three indicators (x_2, x_3, and x_5). In 2020, there was a decrease in the average values of x_1, "The use of information and communication technologies in organisations", x_4, "Number of personal computers", and x_5 "The use of special software" (similar to cluster 2). In 2020, there were 20 regions in the cluster, 3 regions more than in 2015.

For cluster 4, we observed a significant increase in values of x_2 and x_3 by 2020. This may be due to the focus on online sales through websites and social media in the regions included in this cluster. However, the sharp decline in the average value of x_1 and the decrease in x_4 clearly require further analysis. It is necessary to understand whether these phenomena are also related to the pandemic and remote work, or to insufficient funding or other reasons. It is particularly important, as this cluster remains the largest (by 2020, the cluster composition has increased from 27 to 32 regions), which shows a significant gap between a large number of regions and the leaders. In 2018, the average value of x_5 increased, but by 2020 it was back to the level of 2015. This means that the number of organisations using specific software decreased. Expenditures on the introduction and use of digital technologies (x_6) increased moderately compared to 2015.



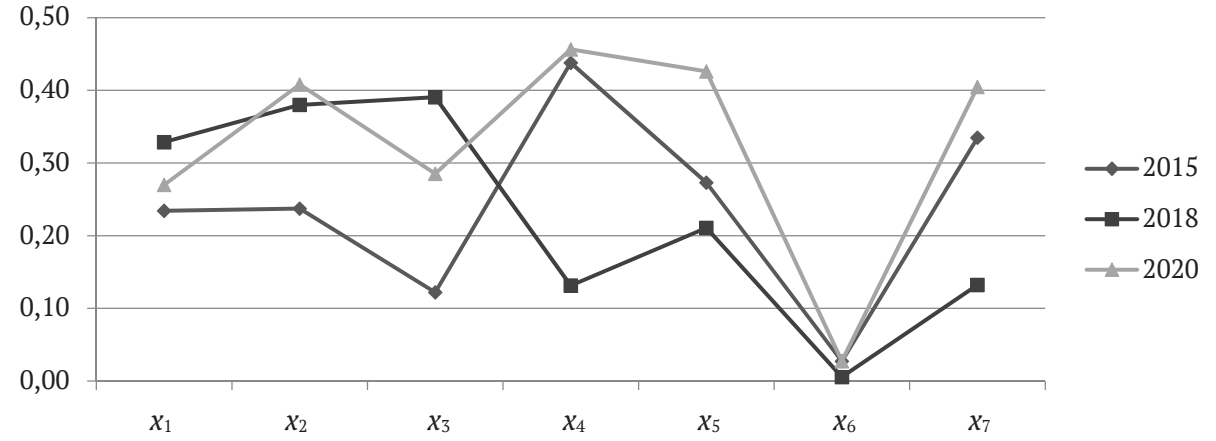
2015 (17)	2018 (20)	2020 (20)
Vologda Region,	Arkhangelsk Region,	Arkhangelsk Region,
Voronezh Region,	Vologda Region,	Astrakhan Region,
Ivanovo Region,	Kaliningrad Region,	Bryansk Region,
Irkutsk Region,	Kamchatka Territory,	Vologda Region,
Kaliningrad Region,	Krasnodar Territory,	Kaliningrad Region,
Kaluga Region,	Krasnoyarsk Territory,	Kostroma Region,
Kamchatka Territory,	Magadan Region,	Krasnodar Territory,
Krasnoyarsk Territory,	Murmansk Region,	Kursk Region,
Magadan Region,	Novosibirsk Region,	Murmansk Region,
Novgorod Region,	Penza Region,	Orel Region,
Penza Region,	Primorye Territory,	Pskov Region,
Perm Territory,	Republic of Adygea,	Republic of Adygea,
Altai Republic,	Republic of Komi,	Republic of Komi,
Ryazan Region,	Republic of Mordovia,	Republic of Tatarstan,
Sakhalin Region,	Sakhalin Region,	Rostov Region,
Tomsk Region,	Tver Region,	Ryazan Region,
Chukotka Autonomous District	Tomsk Region,	Stavropol Territory,
	Tula Region,	Tver Region,
	Tyumen Region,	Tula Region,
	Chukotka Autonomous District	Yaroslavl Region

Fig. 6. Average values of indicators and composition of cluster 3



2015 (27)	2018 (26)	2020 (32)
Altai Territory,	Altai Territory,	Kabardino-Balkarian Republic,
Amur Region,	Amur Region,	Altai Territory,
Arkhangelsk Region,	Bryansk Region,	Amur Region,
Astrakhan Region,	Volgograd Region,	Jewish Autonomous Region,
Bryansk Region,	Jewish Autonomous Region,	Transbaikal Territory,
Sevastopol,	Transbaikal Territory,	Irkutsk Region,
Transbaikal Territory,	Irkutsk Region,	Kamchatka Territory,
Karachay-Cherkess Republic,	Karachay-Cherkess Republic,	Kemerovo Region,
Kemerovo Region,	Kemerovo Region,	Kirov Region,
Krasnodar Territory,	Kirov Region,	Krasnoyarsk Territory,
Kursk Region,	Kostroma Region,	Kurgan Region,
Novosibirsk Region,	Kurgan Region,	Novosibirsk Region,
Orel Region,	Kursk Region,	Omsk Region,
Primorye Territory,	Omsk Region,	Orenburg Region,
Pskov Region,	Orel Region,	Penza Region,
Republic of Buryatia,	Republic of Buryatia,	Perm Territory,
Republic of Kalmykia,	Republic of Kalmykia,	Primorye Territory,
Republic of Komi,	Republic of Crimea,	Republic of Bashkortostan,
Mari El Republic,	Mari El Republic,	Republic of Buryatia,
Republic of Sakha (Yakutia),	Republic of Sakha (Yakutia),	Mari El Republic,
Republic of North Ossetia-Alania,	Republic of North Ossetia-Alania,	Republic of Mordovia,
Rostov Region,	Republic of Tuva,	Republic of Sakha (Yakutia),
Saratov Region,	Republic of Khakassia,	Republic of Khakassia,
Smolensk Region,	Samara Region,	Samara Region,
Tambov Region,	Saratov Region,	Sakhalin Region,
Tula Region,	Ulyanovsk Region	Tyumen Region,
Ulyanovsk Region		Udmurt Republic,
		Ulyanovsk Region,
		Khabarovsk Territory,
		Chechen Republic,
		Chuvash Republic,
		Chukotka Autonomous District

Fig. 7. Average values of indicators and composition of cluster 4



2015 (13)	2018 (3)	2020 (9)
Volgograd Region, Jewish Autonomous Region, Kabardino-Balkarian Republic, Kirov Region, Kostroma Region, Kurgan Region, Omsk Region, Republic of Dagestan, Republic of Mordovia, Republic of Tuva, Samara Region, Tver Region, Chechen Republic	Kabardino-Balkarian Republic, Republic of Dagestan, Chechen Republic,	Volgograd Region, Sevastopol, Karachay-Cherkess Republic, Republic of Dagestan, Republic of Kalmykia, Republic of Crimea, Republic of North Ossetia-Alania, Republic of Tuva, Saratov Region

Fig. 8. Average values of indicators and composition of cluster 5

Cluster 5, the outsiders, shows the most pronounced dynamics among all clusters (Figure 8). For 5 regions out of 7, we registered an increase in the average values of indicators by 2020. The number of lagging regions from 2015 (13 regions) decreased to 3 by 2018 (Kabardino-Balkarian Republic, the Republic of Dagestan, and the Chechen Republic), but in 2020 the number of outsiders was already 9. However, the lagging cluster as a whole improved its values.

An analysis of the cluster composition over time (Table 2) showed that of the 80 studied regions, 18 regions did not change their clusters (in italics) and 31 regions were in a higher cluster in 2020 than in 2015 (in bold). We also identified 6 regions which improved their cluster in 2018, but by 2020 returned to their previous cluster: the Moscow Region, the Smolensk Region, the Ryazan Region, the Novosibirsk Region, the Primorye Territory, and the Republic of Tuva. The remaining 25 regions (underlined) moved to a lower cluster.

Conclusions

This study is of particular importance as it provided the typological groups of regions of Russia with similar characteristics of ICT

Table 2

Cluster membership of regions in different periods

Region	Year			Region	Year		
	2015	2018	2020		2015	2018	2020
Saint-Petersburg	*1*	*1*	*1*	Chukotka Autonomous District	3	3	4
Tyumen Region	1	3	4	Irkutsk Region	3	4	4
Moscow Region	2	1	2	**Tambov Region**	**4**	**2**	**2**
Nizhny Novgorod Region	**2**	**2**	**1**	**Astrakhan Region**	**4**	**2**	**3**
Republic of Karelia	**2**	**2**	**1**	**Pskov Region**	**4**	**2**	**3**
Sverdlovsk Region	**2**	**2**	**1**	**Rostov Region**	**4**	**2**	**3**
Belgorod Region	*2*	*2*	*2*	Sevastopol	4	2	5
Vladimir Region	*2*	*2*	*2*	**Arkhangelsk Region**	**4**	**3**	**3**
Leningrad Region	*2*	*2*	*2*	**Krasnodar Territory**	**4**	**3**	**3**
Lipetsk Region	*2*	*2*	*2*	**Republic of Komi**	**4**	**3**	**3**
Chelyabinsk Region	*2*	*2*	*2*	**Tula Region**	**4**	**3**	**3**
Republic of Tatarstan	2	2	3	Novosibirsk Region	4	3	4
Stavropol Territory	2	2	3	Primorye Territory	4	3	4
Yaroslavl Region	2	2	3	**Bryansk Region**	**4**	**4**	**3**
Orenburg Region	2	2	4	**Kursk Region**	**4**	**4**	**3**
Republic of Bashkortostan	2	2	4	**Orel Region**	**4**	**4**	**3**
Udmurt Republic	2	2	4	*Altai Territory*	*4*	*4*	*4*
Khabarovsk Territory	2	2	4	*Amur Region*	*4*	*4*	*4*
Chuvash Republic	2	2	4	*Transbaikal Territory*	*4*	*4*	*4*
Murmansk Region	2	3	3	*Kemerovo Region*	*4*	*4*	*4*
Republic of Adygea	2	3	3	*Republic of Buryatia*	*4*	*4*	*4*
Smolensk Region	2	4	2	*Mari El Republic*	*4*	*4*	*4*
Republic of Khakassia	2	4	4	*Republic of Sakha (Yakutia)*	*4*	*4*	*4*
Republic of Crimea	2	4	5	*Ulyanovsk Region*	*4*	*4*	*4*
Ivanovo Region	**3**	**2**	**1**	Karachay-Cherkess Republic	4	4	5
Kaluga Region	**3**	**2**	**1**	Republic of Kalmykia	4	4	5
Altai Republic	**3**	**2**	**1**	Republic of North Ossetia-Alania	4	4	5
Voronezh Region	**3**	**2**	**2**	Saratov Region	4	5	5
Novgorod Region	**3**	**2**	**2**	**Tver Region**	**5**	**3**	**3**
Ryazan Region	3	2	3	**Republic of Mordovia**	**5**	**3**	**4**
Perm Territory	3	2	4	**Kostroma Region**	**5**	**4**	**3**
Magadan Region	**3**	**3**	**1**	**Jewish Autonomous Region**	**5**	**4**	**4**
Tomsk Region	**3**	**3**	**1**	**Kirov Region**	**5**	**4**	**4**
Volgograd Region	*3*	*3*	*3*	**Kurgan Region**	**5**	**4**	**4**
Vologda Region	*3*	*3*	*3*	**Omsk Region**	**5**	**4**	**4**
Kaliningrad Region	*3*	*3*	*3*	**Samara Region**	**5**	**4**	**4**
Kamchatka Territory	3	3	4	Republic of Tuva	5	4	5
Krasnoyarsk Territory	3	3	4	**Kabardino-Balkarian Republic**	**5**	**5**	**4**
Penza Region	3	3	4	**Chechen Republic**	**5**	**5**	**4**
Sakhalin Region	3	3	4	*Republic of Dagestan*	*5*	*5*	*5*

development and use by organisations. Of course, the obtained results cannot be directly compared with the rating of digital maturity of regions or a number of other composite digitalisation indicators presented above. Clustering only considers indicators of ICT use by regional organisations and does not take into account the digitalisation of households. However, in our opinion, this is important for analysis of the relationship between digitalisation and innovation activity in the regions. Some of the regions in the resulting classification, such as St. Petersburg, the Moscow, Kaluga, Nizhny Novgorod, Belgorod, Voronezh, Sverdlovsk, Tomsk, and Chelyabinsk Regions, are leaders in digitalisation, while the Republic of Dagestan, the Republic of Tuva, the Karachay-Cherkess Republic, and the Republic of North Ossetia-Alania fall behind. The distribution of other regions between the clusters and their migration is less unambiguous in terms of the progress and potential of digitalisation of the region as a whole. It provides grounds for further analysis of the activities of enterprises in a particular region. Therefore, this study is just another step towards a more comprehensive consideration of the issue.

Obviously, the next steps will include research into the further dynamics, i.e. changes over 2021 and 2022, a detailed study of individual clusters and regions within them, comparing digitisation results with the innovative parameters of regions. We also expect to include a more comprehensive set of indicators in the sub-index "Digitalisation level" for calculating the innovation development index of the regions (Schepina & Maslova, 2022).

Our study will make it possible to identify advantages and bottlenecks in the use of ICT by regional enterprises. It can be used to improve the region's development strategy and to develop regional innovation activities and digital maturity.

Conflict of Interest

The authors declare the absence of obvious and potential conflicts of interest related to the publication of this article.

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Анализ использования цифровых технологий в организациях российских регионов

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Предмет. Цифровизация экономики не только формирует новые условия ведения бизнеса, но и задает вектор развития различных сфер общества. Организации стремятся внедрять цифровые технологии в свои бизнес-процессы для повышения эффективности работы, для налаживания деловых отношений и связей. Распространение цифровых технологий приводит к существенным социально-экономическим изменениям, в том числе повышает уровень конкуренции, заставляя компании быть более мобильными и гибкими, чтобы сохранить конкурентные преимущества. Однако неравномерность процессов внедрения цифровых технологий в регионах не позволяет выработать единые рекомендации по развитию цифровизации. Поэтому необходимо выявить регионы, сходные по тенденциям цифровизации, что позволит определить их слабые и сильные стороны и разработать обоснованные стратегии цифрового развития.
Цели. В данной работе сделана попытка выделить кластеры (типологические группы) регионов по характеристикам использования цифровых технологий организациями регионов РФ, а также проследить трансформацию кластеров в динамике с 2015 по 2020 г.
Методология. Информационной базой исследования явились данные Росстата об использовании цифровых технологий (ИКТ) организациями регионов РФ за 2015, 2018 и 2020 гг. В работе использовались методы статистической кластеризации и сравнительного анализа.
Выводы. В результате проведенного исследования получены типологические группы регионов РФ, имеющих сходные характеристики параметров развития и использования ИКТ организациями за три временных периода. Осуществлен анализ тенденций изменения кластеров и их состава. Проведенное исследование позволит выявить преимущества и «узкие места» в процессах использования ИКТ предприятиями регионов и может быть полезно как для корректировки стратегии развития региона в целом, так и для развития региональной инновационной деятельности и цифровой зрелости.

Ключевые слова: регионы, цифровизация, информационные и коммуникационные технологии, кластеры, инновации.

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Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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