Typologization of Russian Regions by Indicators of Digital Transformation and Economic Growth

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Abstract: Digital transformation is one of the key factors of economic growth, while it is necessary to create optimal conditions for the development of three components: spheres of economic activity; technologies on the basis of which new spheres of the economy will be implemented and an information environment that will ensure effective interaction of all participants in the market economy. The assessment of the development and results of such transformation in the regions of the Russian Federation assumes, as one of the main stages, the definition of the typologization of regions. The purpose of the study is to conduct a cluster analysis, on the basis of which the typologization of regions according to the level of economic development and the use of digital technologies in the regional aspect is carried out. The statistical base of the study was made up of indicators on the use of information technologies of various types, the costs of information technology development, as a parameter of economic development, the indicator was taken – the gross regional product per capita for 2020. As a result of the study, 5 types of clusters were identified and their interpretation was given. The regions that are leaders and highly effective in digital development, as well as regions with a low level of development, have been identified.

1 INTRODUCTION

Digital transformation at the present stage is an essential part of economic growth, social sphere and governance at both the state and regional levels. The goals and objectives of digital transformation are focused on increasing the level of interaction between citizens, organizations and the state based on information and communication technologies, and are generally aimed at improving the quality of life of citizens and economic development. The directions for achieving the goals of digital transformation are reflected at the legislative state and regional level in the following documents: the Strategy for the Development of the Information Society in the Russian Federation for 2017-2030 (Decree of the President of the Russian Federation No. 203 dated 09.05.2017), the program "Digital Economy of the Russian Federation" dated July 28, 2017 No. 1632-p. Regional strategies in the field of digital transformation have also been developed at the regional level, which take into account the specifics of each specific region in this direction (for example, the Strategy in the field of digital transformation of economic sectors, social sphere and public administration of the Volgograd Region (Strategy in the field ..., 2021)). These documents note that digital data is a key factor in the development of the economy.

The transition to the digital economy in Russia requires monitoring of this process and the formation of a theoretical and methodological approach to assessing the results achieved. The scientific literature also presents studies reflecting aspects of the development of digital technologies and the digital economy at the regional level (Batrakova L. G., 2019; Larin S.N., 2020), approaches and methods for the formation of new indicators and methods for identifying inequalities in the development of the digital economy in the regions of the Russian Federation are being developed (Arkhipova M. Yu., Sirotin V. P., 2019.); priorities of digital development

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of regions are determined in accordance with Russian legislation (Asalieva Z. A., 2022). Special attention is also paid to the issues of readiness of regions for digital transformation, the construction of a rating of regions by the level of digital development (Pisarev I.V., Exev V.I., Panteleeva I.A., Parfentieva K.V., 2022.), the impact of changes in the framework of digital transformation on regional development is studied (Zemtsov S.P., 2021), emphasis is placed based on the fact that there is a significant differentiation of regions depending on the introduction and use of information technologies. In the study of Potapova O.A., an interesting approach to the classification of regions according to the readiness of their transition to the digital economy is proposed, but there is no testing of it on specific regions (Potapova O., 2020). Thus, when forming the basis of empirical and theoretical research, it is advisable to take into account regional peculiarities in the transition to the digital economy in accordance with the goals and objectives set at the state level; and also pay special attention to identifying regional problems in the implementation of the digital transformation strategy.

In this regard, the formation of methods and ways for tracking the development of the digital transformation of the economy of the region becomes relevant, while it can be said that the result of their implementation can be indicators of the use of digital technologies of various types at the regional level.

2 MATERIALS AND METHODS

Evaluation of the results of the digital transformation of the economy of the regions of the Russian Federation assumes one of the main stages of typologization. Cluster analysis has been chosen as the main method of classification of regions, which allows for multidimensional groupings of research objects.

To conduct a cluster analysis of the regions of Russia, in order to identify similar groups of regions in terms of economic development and the use of digital technologies, official data from the statistical publication of the Federal State Statistics Service "Regions of Russia. Socio-economic indicators" for 2020 were used (Federal State Statistics Service, 2022), the sample consisted of 82 observations. The list of indicators includes the following:

X_1 – Use of personal computers, in %;

X_2 – Use of servers, in %;

X_3 – Use of LAN, in %;

X_4 – Use of "cloud" services, in %;

X_5 – Use of mobile Internet by organizations, in %;

X_6 – Use of broadband Internet access in organizations, in %;

X_7 – Organizations with a website, in %;

X_8 – Use of special software tools in organizations, in %;

X_9 – Costs for the introduction and use of digital technologies, million rubles;

X_{10} – Use of the Internet by the population, in %;

X_{11} – Gross regional product per capita, rubles;

X_{12} – GVA by industry: activities in the field of informatization and communications, %.

This system of indicators reflects the achieved level of economic development and indicators of the use of digital technologies.

In the study, the results of cluster analysis were obtained based on the results of two methods: hierarchical cluster analysis and clustering by k-means (Vukolov E.A., 2004; Petrova E.A., 2017). The purpose of clustering is to detect groups of similar objects that can be combined into a single cluster.

3 RESULTS AND DISCUSSION

The graphical result of the hierarchical clustering method (including calculations of Euclidean distance and Ward's method) is represented by a dendogram, the analysis of which makes it possible to identify 5 types of regions united in clusters that contain objects closest to each other according to the presented indicators (X_1-X_{12}).

Since the number of clusters has already been determined, we will divide all 82 observations into 5 clusters using the k-means method. In order to justify the number of certain clusters, we will analyze the graph of the average values of variables for each cluster (Fig. 1, 2). Figure 1 shows the values of the averages of all the variables studied. At the same time, the values of variables X_9 (Costs for the introduction and use of digital technologies, million rubles) and X_{11} (Gross regional product per capita, rubles) are most sharply traced, which is due to their unit of measurement, which differs significantly on the scale from the rest X_i. Judging by the graph, the average values of X_{11} differ sharply in all 5 clusters, while in X_9 the highest values are observed only in 1 cluster.

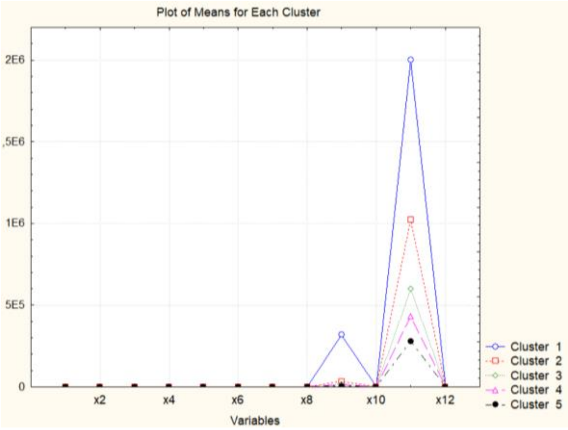

Figure 1: Graph of means for variables X $_{8}$-X $_{12}$. Source: Compiled by the authors based on (Federal State Statistics Service, 2022).

In order to see the distribution of the average values for the remaining variables, we reduce the value of the vertical scale (Fig.2).

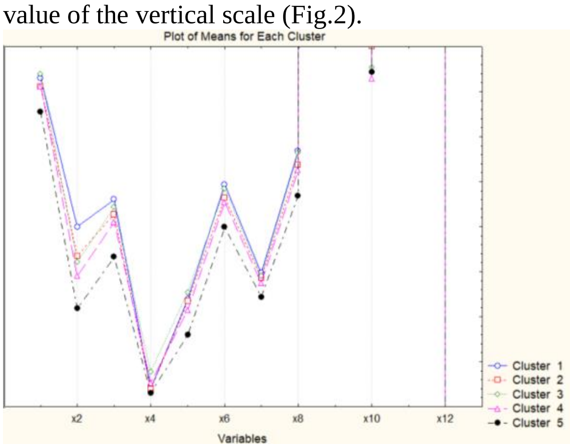

Figure 2: Graph of means for variables X 1-X 8. Source: Compiled by the authors based on (Federal State Statistics Service, 2022).

In Fig. 2 it can be seen that cluster No. 1 has the highest values in almost all indicators. For 2, 3, 4 clusters, the positions of the average values are not constant. For cluster No. 5, the average values for all indicators will be minimal, therefore, the regions included in cluster No. 5 are characterized by both low economic development and low development of digital transformation. This is what determined the expediency of allocating the number of clusters equal to 5. Since an increase in the number of clusters will only lead to additional groupings of regions with low development in this aspect.

As a result of the analysis of the obtained features, the distribution of regions by clusters is obtained (Fig. 3).

Cluster 1 includes 5 regions that are leaders in economic development and the use of digital technologies; cluster 2 also includes 5 regions that are characterized as economically highly developed regions with an average level of use of digital technologies; cluster 3 is represented by 20 highly efficient regions for the use of digital technologies with an average level of economic development; cluster 4 includes 28 regions with an average level of economic development and the use of digital technologies; cluster 5 includes 24 regions with a low level of economic development and the use of digital technologies.

		GENERAL CHARACTERISTICS OF THE CLUSTER
1 cluster – 5 regions	Chukotka Autonomous Okrug, Sakhalin Oblast, Magadan Oblast, Tyumen Oblast, Moscow	leaders in economic development and the use of digital technologies
2 cluster – 5 regions	Republic of Sakha (Yakutia), Murmansk region, St. Petersburg, Krasnoyarsk Krai, Kamchatka Krai	economically highly developed regions with an average level of digital technology use
3 cluster – 20 regions	Komi Republic, Arkhangelsk Oblast, Moscow Oblast, Republic of Tatarstan, Leningrad Oblast, Khabarovsk Krai, Belgorod Oblast, Irkutsk Oblast, Sverdlovsk Oblast, Primorsky Krai, Amur Oblast, Kaluga Oblast, Lipetsk Oblast, Vologda Oblast, Perm Krai, Orenburg Oblast, Kaliningrad Oblast, Astrakhan Oblast, Republic of Karelia, Tomsk Oblast	highly efficient regions for the use of digital technologies with an average level of economic development
4 cluster – 28 regions	Samara Region, Republic of Khakassia, Nizhny Novgorod Region, Yaroslavl Region, Kursk Region, Tula Region, Novosibirsk Region, Novgorod Region, Chelyabinsk Region, Krasnodar Region, Voronezh Region, Udmurt Republic, Republic of Bashkortostan, Ryazan Region, Vladimir Region, Rostov Region, Trans-Baikal Territory, Jewish Autonomous Region, Omsk Region, Volgograd Region, Kemerovo region, Tver region, Orel region, Smolensk region, Penza region, Tambov region, Ulyanovsk region, Saratov region	regions with an average level of economic development and the use of digital technologies
5 cluster – 24 regions	Bryansk Region, Republic of Kalmykia, Republic of Mordovia, Pskov Region, Kostroma Region, Kirov Region, Republic of Adygea, Stavropol Territory, Republic of Buryatia, Sevastopol, Kurgan Region, Altai Territory, Republic of Mari El, Chuvash Republic, Republic of Altai, Ivanovo Region, Republic of Crimea, Republic of North Ossetia – Alania, Republic of Tyva, Republic of Dagestan, Kabardino-Balkarian Republic, Karachay-Cherkess Republic, Chechen Republic, Republic of Ingushetia	regions with a low level of economic development and the use of digital technologies

Figure 3: Typologization of Russian regions by the effectiveness of the use of digital technologies and the development of the economy. Source: Compiled by the authors based on (Federal State Statistics Service, 2022).

Table 1 shows the average values of clusters, on the basis of which their distinctive features are determined and confirm the identified characteristics.

Table 1: Average values of clusters of regions.

Indicators	Cluster 1 – leaders in economic development and the use of digital technologies	Cluster 2 – economically highly developed regions with an average level of use of digital technologies	Cluster 3 – highly efficient regions for the use of digital technologies with an average level of economic development
X_1	84	82	84.6
X_2	55	49	48.2
X_3	60	57	58.8
X_4	23	23	26.8
X_5	41	41	42.2
X_6	63	61	62.4
X_7	46	45	45.4
X_8	70	67	69.3
X_9	318079	32157	16308.9
X_{10}	91	90	85.9
X_{11}	2000119	1021213	598683.3
X_{12}	2	2	1.9

Continuation of Table 1:

Indicators	Cluster 4 – regions with an average level of economic development and the use of digital technologies	Cluster 5 – regions with a low level of economic development and the use of digital technologies
X_1	82.3	77.3
X_2	45.4	39.1
X_3	55.9	49.1
X_4	24.6	22.7
X_5	38.8	33.9
X_6	59.7	54.9
X_7	44	41.3
X_8	66	61
X_9	11325.1	3255.8
X_{10}	83.7	85.1
X_{11}	430498.1	279255.8
X_{12}	2.2	2.2

Source: Compiled by the authors based on (Federal State Statistics Service, 2022).

4 DISCUSSIONS

Analyzing the data in Table 2, according to the values of the gross regional product per capita, 5 regions (Chukotka Autonomous Okrug, Sakhalin Oblast, Magadan Oblast, Tyumen Oblast, Moscow) were determined as absolute leaders in economic development (average value 2000119), included in cluster 1 and 5 regions (Republic of Sakha (Yakutia), Murmansk Oblast, St. Petersburg, Krasnoyarsk Krai, Kamchatka Krai) are also significantly leading in economic development, despite the fact that the average value is 1021213, which is almost 2 times less than in cluster 1, but almost 2 times more than in cluster 3. But, despite the high level of economic development in Cluster 1 and 2, cluster 2 is significantly inferior in terms of the use of digital technologies. This is confirmed by the average values of the other variables, which are significantly lower than in cluster 1. It can be assumed that this trend is due to the low level of costs for the introduction and use of digital technologies, but this is not confirmed by the analysis of other clusters.

For example, cluster 3 includes regions characterized as regions with an average level of economic development in terms of GRP per capita and low costs for the introduction and use of digital technologies, however, in terms of the use of digital technologies, they are significantly ahead of cluster 2 and the values of the averages of most variables approach the values of the averages of cluster 1, and for X_1, X_2 and X_5 even exceed them. Therefore, cluster 3 is marked as highly efficient in terms of the effectiveness of the ongoing digital transformation. The leaders of cluster 3 are such regions as Belgorod Region, Arkhangelsk Region, Republic of Tatarstan, Leningrad Region, Tomsk region.

The values of the averages for 4 and 5 clusters are lower than the first three and are characterized as medium-developed and low-developed in terms of economic development and the use of digital technologies, respectively.

5 CONCLUSION

The results of cluster analysis obtained within the framework of the conducted research make it possible to monitor this process and identify both regions with effective use of information technologies and regions that lag behind in development in this direction. As a result of the conducted research, the main indicators characterizing the results of digital transformation in the use of digital technologies were identified, the costs of technology development and the gross regional product per capita were taken into account, according to which regions can be classified by type depending on the level of economic development and the degree of use of digital technologies. It is assumed that the effective use of digital technologies should contribute to the effective economic development of each region. The results of cluster analysis revealed 5 types of clusters in which this trend can be traced. In most clusters, the level of use of digital technologies corresponds to the level of economic development of the region. The resulting typologization of regions according to the level of economic development and the use of digital technologies can become the basis for the development of digital development programs at the federal level, which will take into account the characteristics of each cluster, will allow the formation of the most effective support measures. At the level of the subjects of the Russian Federation, this typology allows us to identify the most problematic areas of development for digital transformation and identify key performance indicators of the processes under study, which will allow us to adjust the indicators of the developed strategies ((Decree of the President of the Russian Federation No. 203 dated 09.05.2017; The program "Digital Economy of the Russian Federation" dated July 28, 2017 No. 1632-p).

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