Digitalisation of the Economy and Regional Development

Irina Turgel, Alexander Pobedin, and Aksana Panzabekova

Abstract The digitalisation of industry is an urgent aspect to develop regional economic systems, which involves introducing state-of-the art information and communication technologies into the activities of enterprises. Digital transformation is accompanied by a corresponding transformation of the structure of interregional interactions, influencing the depth and degree of regional differentiation, as well as the competitiveness of individual constituent entities of the Russian Federation. In this article, the authors assess the impact of digitalisation on the development of regions of the Russian Federation by determining the depth of digital transformation and the unevenness of digitalisation processes among the constituent entities of the Russian Federation. The purpose of the research is to study the digital transformation processes in a territorial context taking into account its impact on territorial differentiation and the cyclical nature of economic development. As a result of the research, the authors determined that in most constituent entities of the Russian Federation, the second stage of digital transformation is being implemented, while the country's territory is highly differentiated in terms of digitalisation performance. The authors have proposed several possible scenarios for the implementation of digital transformation processes in Russian regions.

Keywords Industry 4.0 · Regional development · Digital transformation · Spatial differentiation

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1 Introduction

The current stage of development of the world economic system can be characterised by a high degree of variation and dynamism, as reflected in the state of individual subsystems and processes. Technological innovation is a key driving force behind these sweeping changes. In the context of accelerating socio-economic processes, a prerequisite for the competitiveness of both individual enterprises and regional economic systems is the synchronous transformation of production processes in line with new technological requirements [24]. Currently, digitalisation is an integral part of such a transformation. Companies that were the first to make their way through digital transformation significantly outperform competitors due to higher productivity of both labour and equipment, lower costs, and increased safety of production processes, which is accompanied by significant changes in the activities of enterprises and business model adjustments. A typical feature of the early twenty-first century is the transition to the so-called Industry 4.0, within which digitalisation encompasses both all the most important processes of the production chain and the organisation of inter-firm interactions [14].

In Russia, the foundations of digital transformation were laid in the Strategy for the Development of the Information Society in the Russian Federation in 2017–2030, as well as in the Programme "Digital Economy of the Russian Federation", which provides for incentives to digitise all the key sectors of the Russian economy. The most important condition for successful digitalisation in Russia is to provide stakeholders in economic processes with access to modern network technologies, programmes, new digital equipment, and ICT technologies based on access to the Internet and other modern data transmission channels [6].

The digitalisation of industry goes along with the introduction of new types of equipment based on robotics, resource-saving and waste-free technologies, as well as production automation. Contemporary information systems ensure prompt decision-making and productivity growth of all factors of production, increased competitiveness, development of new technological solutions, and introduction of them into production.

These processes claim special attention at the regional level. Russia is characterised by high differentiation of territorial development, when the spread between the conditions and indicators of individual regions can reach high values. In this context, digital transformation can become a powerful driver of territorial development, serve as a mechanism to overcome the lag of individual regions, and improve their competitiveness by contributing to the balanced development of the entire country. In this work, the authors set the goal to study the digital transformation processes in a territorial context taking into account its impact on territorial differentiation and the cyclical nature of economic development.

2 Literature Review

The digital transformation of both the socio-economic system as a whole and individual subsystems, including industry, is a major focus of interest of the research in the modern scientific community [23]. A statistical analysis of the impact of the degree of digitalisation on the level of economic development, investment, and employment is carried out [6, 9, 13, 15, 18, 22]. Some researchers emphasise a stable positive relationship between the development of contemporary information infrastructure (including the Internet speed) and the economic growth rate [3, 21].

Separately, researchers consider the features of digitalisation processes in various countries and regions including developed ones [5] in the Asia–Pacific Region [11], Africa [8, 17, 20], Arab countries [25] and Russia [12, 19, 27].

Special mention should be made of the works that reveal the theoretical and methodological features of digital transformation processes. In the study by Vertakova et al. [26], the structure of transformation processes in the economic system is analysed; the following levels of digital transformation of industry are distinguished: the level of existence (change in objects and subjects of social consciousness), the level of manifestation (change in conditions, values), and the level of implementation (implemented changes).

Some researchers focus on the digitalisation of industrial enterprises. Kovalchuk and Stepnov [10] introduce the "new digital space" concept, which includes enterprise production processes implemented in the digital environment. Behrendt [4] distinguishes business processes, primarily transferred to the digital environment. Maltseva and Bragina [13] explore the possibilities of increasing labour productivity through digital transformation.

Glezman et al. [7] highlight the basic properties of digital technologies (innovation, integrability, criteria, flexibility, minimality, and functionality), as well as key stages of digitalisation, such as computerisation of industry, provision of network exchange, application of innovative software, production of digital devices and components, production of robotics, implementation of digital management models, creation and implementation of cyber-physical models. In the monograph edited by Lavrikova, Doctor of Economics Andreeva [1] considers the prerequisites for the digital transformation of the Russian industry and provides a methodology for assessing digitalisation.

Some authors consider the digital transformation processes in the context of individual regions [2, 7].

However, there is a shortage of works that consider the digital transformation processes in the context of the interregional differentiation processes considering the impact of the ICT integration into the economic system on the regional development processes.

3 Material and Methods

The informational background of the research was made up of digital society development indicators in the regions of the Russian Federation published on the official website of the Federal State Statistics Service (https://rosstat.gov.ru/). For the analysis, the following indicators of the constituent entities of the Russian Federation were selected: the proportion of entities that used personal computers, the entities' costs associated with the deployment and use of digital technologies, the number of professionals in information and communication technologies, the proportion of entities that analysed big data (in % of the total number of entities), the share of entities by the area of using IoT technologies (in % of the total number of entities) in the energy consumption optimisation and automation of production processes, management of logistics and product movement, the volume of gross regional product, the volume of shipped goods of its own production, works and services performed on their own by economic activity. The analysis used the most recent data published at the time of writing, for 2020 or 2019, as well as the trend data over the past 10 years, if available.

A variation factor was used as the main indicator of territorial differentiation; the maximum, minimum and average values were also determined. In addition, according to individual indicators, ranking was carried out, as well as leaders and those lagging behind among the regions were determined.

For the Tyumen and Arkhangelsk Regions, data without taking into account the autonomous areas in order to avoid duplication of information (the Khanty-Mansiysk, Yamalo-Nenets and Nenets autonomous area were analysed separately) were used.

A correlation analysis with the Pearson coefficient was carried out; control calculations of the Kendall and Spearman Tau-b coefficients were also carried out. For calculations and analysis, the SPSS statistical package tools were used.

When classifying the stages of digitalisation, as well as the criteria and indicators used for each stage, the authors used the previous research results including the monograph edited by Lavrikova and Andreeva [26, pp. 184–188], where the stages of digital transformation of industry are distinguished as follows: (1) primary information and communication digitalisation; (2) electronic data sharing with external network partners; (3) use of custom software; (4) production of information and communication technologies and equipment; (5) production and use of robots and sensors (industrial Internet).

A feature of this research, which determines the scientific novelty, is the study of the stages of digital transformation of the economy in the context of the uneven social and economic development of Russian territories. The authors assumed that digital transformation can become a tool to reduce disproportions in territorial development, as well as enhance the stability of regional social and economic systems against the consequences of unfavourable macroeconomic environment.

4 Results

At the moment, Russia consists of 85 constituent entities of the Federation including 22 republics, 46 regions, 9 territories, 3 cities of federal significance, 4 autonomous districts and 1 autonomous region. The constituent entities of the Russian Federation can be characterised by a high degree of heterogeneity of social and economic development; for example, Moscow accounts for 21% of the gross regional product of all regions of the country, 20% of all economic funds, 15% of retail trade turnover, while Moscow is home to 8.6% of the population of Russia. For comparison, the share of the Sverdlovsk region, one of the regions advanced in industrial development, in which 2.9% of the country's population live (and the region includes a city with over a million people), accounts for only 2.7% of the gross regional product in the Russian Federation.

Historically, Russian industry has been a territorial development driver by strengthening the internal and external ties of regions, determining the employment pattern and increasing the competitiveness of individual territories. However, the third and fourth industrial revolutions significantly change the role of legacy industries by presenting new demands and providing new opportunities. Currently, a quarter of the Russian GDP is accounted for by industrial products but the consequences of global transformation processes are increasingly affecting the activities of Russian enterprises in most Russian regions, the share of the industrial sector is steadily decreasing each and every year. Digital transformation in industry is a necessary response to the challenges of a new stage in the development of the world's economic system, and it is carried out in stages [1]. At the first stage of digital transformation, industrial enterprises are computerised; in most Russian regions, this stage should be recognised as completed (see Fig. 1). The transition to the second stage means high integration of information technologies into the external and internal relations of an enterprise. Document flow, accounting, HR recordkeeping, and some other processes begin to be carried out with the features provided by the contemporary IT environment.

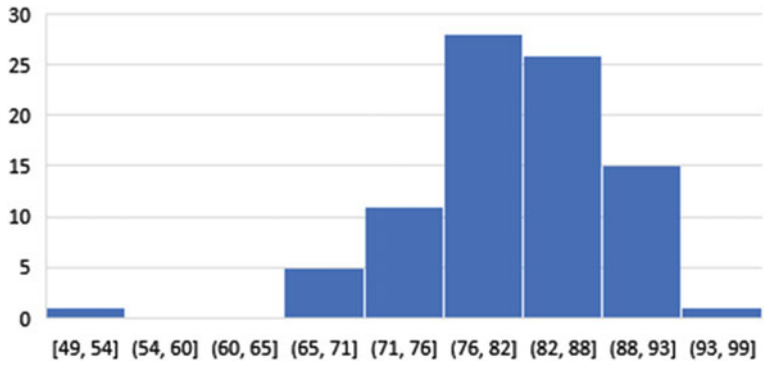

Fig. 1 Distribution of constituent entities of the Russian Federation by the share of entities that used personal computers (2020, %)

At the third stage, the IT environment tools are used to enhance the efficiency of management activities, research and development, procurement, and sales management. A significant part of the processes in entities is carried out through corporate automation tools represented by CRM, ERP, and SCM systems. At the moment, many regions are going through this stage, the distribution of the constituent entities of the Russian Federation by the number of entities with CRM, ERP, and SCM systems is extremely uneven (see Fig. 2).

The fourth stage of digitalisation goes along with the development of its own information products and technologies. Among the most important trends at this stage are the Internet of Things, the use of electronic twins, the widespread use of big data analysis in management decision-making collected through the contemporary information environment tools.

According to the 2020 data, in most of the Russian regions, the proportion of entities, that use big data analysis, does not exceed 3–5% (Fig. 3); in Moscow, which is the digitalisation leader among the constituent entities of the Russian Federation, the proportion of such entities is 8%, and the Internet of Things integrated into

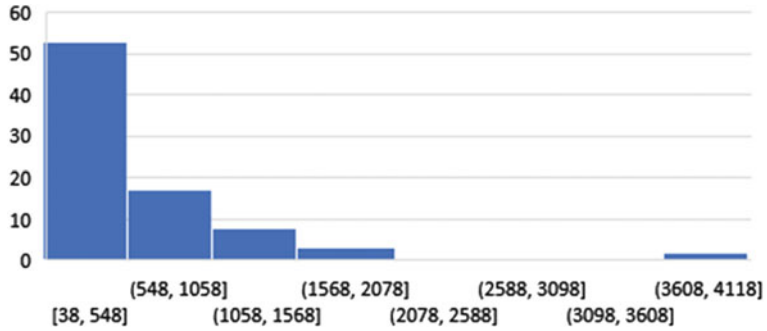

Fig. 2 Distribution of constituent entities of the Russian Federation by the number of entities that had CRM, ERP, and SCM systems (2019, %)

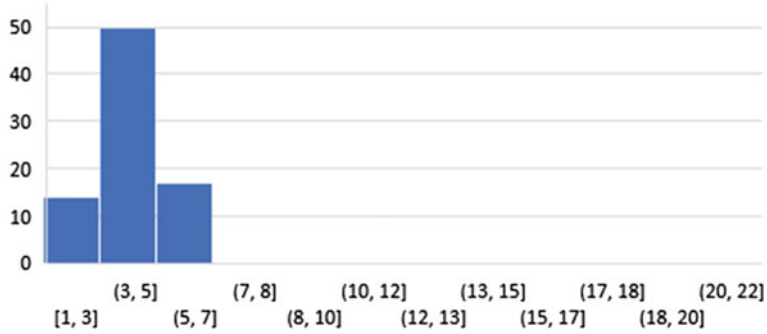

Fig. 3 Distribution of constituent entities of the Russian Federation by the share of entities that use Big Data (2020, %)

activities of 10%, on average in Russian regions, only 3–4% of entities use the Internet of Things.

To assess territorial differentiation according to the degree of digitalisation of regional economic systems, the variation factor was used, and also, as additional indicators, the ratio of the minimum and maximum values of indicators among the constituent entities of the Russian Federation with the average was calculated. In addition to special indicators of the information economy, general economic indicators were also considered, such as GRP and the volume of products shipped, in order to compare the differentiation in the field of digitalisation and the level of interregional differentiation in the country as a whole. For the calculations, the 2020 data were used, except for two indicators, since at the time of preparing the material, the data had not yet been published. The calculation results are presented in Table 1.

As can be seen from the data presented, the degree of differentiation in terms of the economy digitalisation parameters differs significantly depending on the specific

Table 1 Differentiation of constituent entities of the Russian Federation by certain economic indicators

Indicator	Min/mean	Max/mean	Coefficient of variation
Costs of entities associated with the implementation and use of digital technologies, 2020	0.02	51.16	1.36
Number of information and communication technology professionals, 2020	0.04	20.84	0.93
Number of entities that had CRM, ERP, and SCM systems, 2019	0.06	6.09	0.68
Proportion of entities that analysed big data (as a percentage of the total number of surveyed entities), 2020	0.33	4.87	0.24
Proportion of entities by areas of use of IoT technologies (as a percentage of the total number of surveyed entities), 2020			
Optimisation of energy consumption (electrical, heat) in the territory of the entity	0.33	3.04	0.32
Automation of the production flows, management of logistics, and product movement	0.23	3.04	0.36
GDP, 2019	0.05	17.26	0.89
Volume of the shipped goods of own production, works, and services performed on their own, 2020			
Mining operations	0.001	14.89	1.32
Manufacturing	0.001	13.19	0.92

indicator. The largest gap between the constituent entities of the Russian Federation is recorded in terms of the entity's costs for the use of ICT, and the maximum value differs from the average by more than 50 times. For this indicator, the ranking result is quite expected; the cities of Moscow and St. Petersburg, as well as the Moscow, Samara, and Astrakhan Regions, are in the top five. The Chukotka Autonomous Region, the Altai Republic, the Tyva Republic, the Karachay-Cherkess Republic, and the Jewish Autonomous Region are at the bottom of the list. In terms of the number of ICT specialists, interregional disparities are also significant, although less pronounced than in terms of the volume of ICT expenditures, the variation factor was 0.93, and the best indicator was 20 times higher than the average. Moscow, St. Petersburg, and the Moscow Region are also in the lead here but the Sverdlovsk Region and Tatarstan rank 4th and 5th. As far as the rest of the digitalisation indicators are concerned, the gap between the territories is significantly lower. In terms of the number of entities with the CRM, ERP, and SCM systems, the variation reaches 0.68, the leader (Moscow Region) is only six times higher than the average. Differentiation by the share of entities analysing big data and using the Internet of Things is not high. It should be noted that the territorial asymmetry in terms of digitalisation parameters is quite comparable with the asymmetry in relation to general economic indicators.

In terms of dynamics, it is of interest to consider changes in the interregional differentiation parameters in terms of the volume of goods shipped (in general and in relation to innovative products) (see Fig. 4).

As can be seen from the above calculations, the general economic differentiation between territories is very stable, although it has tended to increase over the past 10 years (the variation factor increased from 0.91 to 0.95). However, the differences in the volume of production of innovative products over the period under review changed significantly and clearly showed two periods, from 2010 to 2013 and from

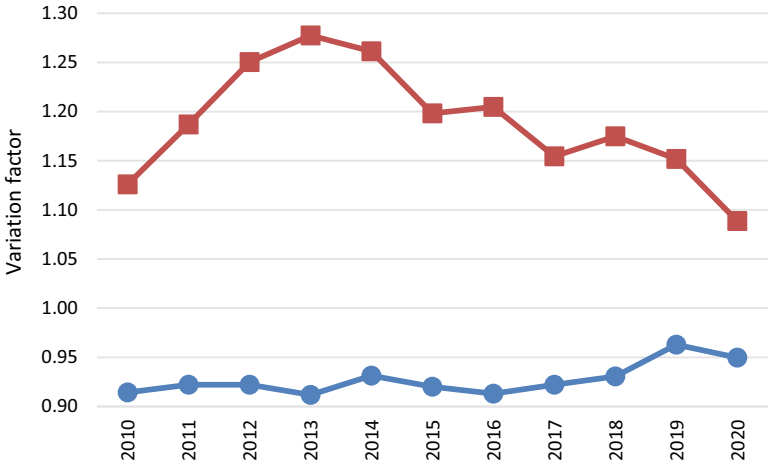

Fig. 4 Differentiation of the constituent entities of the Russian Federation by shipped goods of their own production, works and services performed on their own (variation factor)

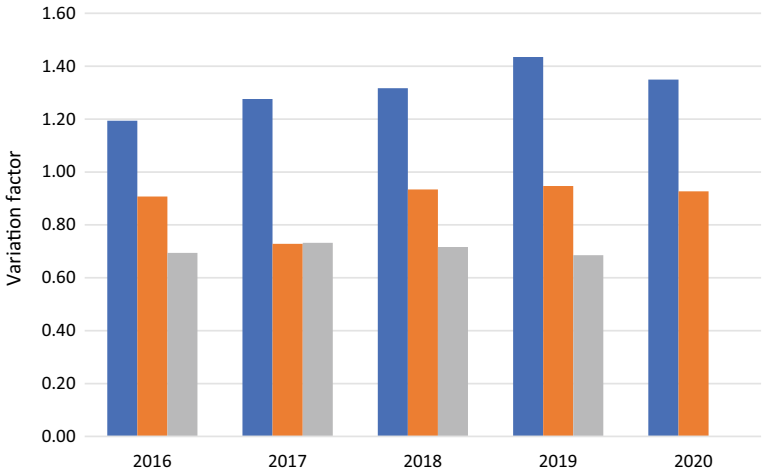

Fig. 5 Differentiation of subjects of the Russian Federation by economy digitalisation indicators (variation factor)

2013 to 2020. During the first period, interregional differentiation increased rapidly, from 1.13 to 1.28; in subsequent years, on the contrary, there was a decrease to 1.09; the influence of macroeconomic dynamics is very likely here since the period of 2014–2015 can be characterised by a decrease in economic growth in Russia, a sharp collapse of the national currency and a deterioration in some other indicators. Therefore, the leading regions during this period slow down innovation activities allowing other territories to narrow the gap.

Unfortunately, it is not possible to trace the information transformation trend data at the territorial level over 10 years for most indicators; based on the available data, the analytic horizon is limited to a period of 4–5 years (even then, not in all areas of analysis). Figure 5 shows the interregional differentiation trend data in the ICT costs of entities, the number of ICT staff, and the number of entities that use high-tech information systems (including CRM). According to the considered indicators, the inter-territorial differentiation in the country is quite large but its changes are not always linear. The gap between regions in ICT spending widened from 2016 to 2019 along with the relatively stable macroeconomic parameters of the country as a whole; but in 2020, the differentiation is decreasing amid economic problems associated with the pandemic. A similar pattern has already been noted for the innovative goods shipped. Differentiation in terms of the number of ICT specialists and the number of entities with CRM systems changes without a clear trend; it increases in some years while decreasing in others, and the reason is most likely in the nature of the considered indicators which measure the presence of a certain phenomenon but not the efficiency of economic activities; it is preferable to increase the volume of cost indicators reflecting the digitalisation results; unfortunately, most indicators in this area currently officially published in Russia, are not that kind but record only the quantitative and not qualitative side of the introduction of digital technologies.

Table 2 Calculation of the correlation matrix in relation to the industrial production index for the constituent entities of the Russian Federation and some economy digitalisation data (unloading from the SPSS information complex)

Indicator	ICT costs	ICT staff	CRM	Bigdata	Internet of Things, production	Internet of Things, power sector
Pearson correlation	−0.136	−0.130	−0.060	−0.048	−0.058	−0.074
Value (double-sided)	0.214	0.236	0.580	0.662	0.595	0.500
N	85	85	85	85	85	85

To conclude the analysis, it is required to test the hypothesis about the stabilising role of digital transformation processes for regional development; they enhance the economic system resilience in dealing with adverse environmental factors. There are studies stating a positive relationship between the development of the ICT sector and economic growth in the regions [16] but they did not consider the impact of digitalisation on the dynamics of economic growth during the crisis period.

The traditional arsenal of correlation analysis is quite suitable for measuring the presence of a relationship between ICT development and the sustainable development of regions. Since 2020 is the most recent crisis year in the country's development in the historical perspective, it was decided to use the industrial production index for April 2020 as an indicator of a region's macroeconomic stability, when there was a significant deterioration in economic dynamics. In relation to this indicator, a comparison with the regional digitalisation indicators used earlier to analyse territorial differentiation was made (Table 2).

For the calculations shown in Table 2, the Pearson correlation as the most popular toolkit was used; however, similar calculations with the Kendall and Spearman Tau-b coefficients were carried out, which, however, did not provide any significant differences in the results obtained. The assumption that digitalisation development reduces the vulnerability of a region is not confirmed. For all five investigated digitalisation parameters, no significant correlation between the variables was found. Therefore, in April 2020, the economic dynamics in the regions deteriorated regardless of the development of the ICT sector, although the global trend indicates that it was the IT sector companies that proved to be the most resilient to the crisis consequences, also due to the increase in remote forms of communication between market entities and the increased use of IT infrastructure. It is possible that a higher degree of digital transformation is required to manifest such an effect than is currently in the Russian regions. According to the authors, this issue is still relevant and requires further study with broader statistics.

5 Discussion

Differentiation of territorial development is a fairly typical phenomenon, especially for spatially extended countries. The determining factors of inter-territorial disparities can be various climatic and geographic conditions, uneven natural resource base, uneven distribution of production facilities and the existing settlement system, development of transport infrastructure, etc. A major factor determining the importance of individual regions in the inter-territorial ties is economic growth and its determinants including technical progress. In the context of the transition to another technical and economic setup determined by the parameters of Industry 4.0, it seems very timely to assess the consequences of the new technological revolution for spatial and regional development, since there is an opportunity to direct and adjust the spatial projection of digital transformation at the initial stage of technological changes.

Previous studies have proven the significant impact of digitalisation on regional development. There are positive effects of digital transformation on the growth of labour and capital productivity, and the rate of economic growth. In particular, using regression analysis tools, the direct impact of the labour and capital digitalisation on regional growth has been proven; it is measured through the number of people employed in the ICT sector and the ICT costs of entities [16].

However, the impact of digitalisation is not always limited to any positive effects. In particular, a possible variant of a destructive digital transformation is considered, which can be characterised by rapid and radical changes in enterprises; it results in impairing the ability to compete and undermining the financial potential of firms [24].

Three scenarios of digital transformation can be considered in the context of the impact on the regional development processes (see Table 3).

Among the above options, the third scenario is undoubtedly the best, although the implementation should be accompanied by the improved implementation of industrial policy measures and an increase in the transparency of mechanisms for distributing financial assistance between regions. In the current situation, the second scenario is more likely, which can be partially confirmed by the research results. Implementation of the first scenario should be recognised as the most negative option, while the technological inferiority of certain territories will not be preserved, but there will be a significant loss of the competitive edge by the national economy as a whole.

6 Conclusion

Based on the research conducted, the main conclusions can be formulated as follows.

At first, the digital transformation process in Russia as a whole and in the regions of the Russian Federation can be considered to have begun; in recent years, investments in the ICT sector have grown significantly, employment in this area has increased, and government support measures have increased.

Table 3 Scenarios of the effects of digital transformation on the territorial development in Russia

Scenarios	Rate of digital enablement	Spatial coverage	Digital investment performance	Implications for territorial differentiation
Scenario 1	Slow	Narrow, first of all—the largest urban agglomerations—Moscow and St. Petersburg, to a lesser extent—other million-plus cities, as well as regions with a priority order of financial support	Low, part of the funds, including those allocated with the state support, were invested in unpromising projects or outdated technological solutions that do not allow providing enterprises with a competitive edge	Insignificant, due to weak economic effects
Scenario 2	Average	Narrow, primarily covers regions with a high concentration of labour and capital resources, in addition to large cities—regions with a high resource and industrial potential	Average, part of new digitalization projects turn out to be highly effective, providing an opportunity to reduce the cost of current production or increase production of fundamentally new products	Strengthening territorial differentiation, the leaders of past years consolidate their position, backward and depressed territories lag even further in the socio-economic development
Scenario 3	Above average, approaching the pace of digital transformation in leading overseas countries	Substantial spatial coverage—from 30 to 60% of the constituent entities of the Russian Federation (over time), also through ensuring competitive access to financial support with equalizing coefficients by area	Above average, including due to wide spatial coverage and general agglomeration effect on the country's economy	Smoothing differentiation by strengthening economic growth and increasing the investment attractiveness of areas presenting a problem in the past

Secondly, it can be stated that the first stage of digital transformation is complete, and it is accompanied by large-scale computerisation of the economy. At present, the second stage is well in progress, and the transition to the third stage is being carried out, but this process is accompanied by extreme territorial unevenness, so far, signs of the fourth stage can be recorded only in an insignificant number of regions not exceeding 10% of the constituent entities of the Russian Federation on average.

Third, the differentiation of regions according to individual digitalisation indicators in general coincides with the average values of general economic differentiation, which is also typical of the past periods of the country's development. The accuracy of current analytics is hampered by the scarcity of the information base on digital transformation processes provided by official Russian statistics.

Fourthly, unfortunately, the scale of digital transformation does not yet make it possible to significantly reduce the impact of crisis factors on regional development; perhaps further integration of digital technologies will make it possible to increase the stability of regional socio-economic systems, as the experience of foreign countries shows.

Fifthly, at the moment, one can state the provided "window of opportunity" for the implementation of one of the three key scenarios for the impact of digital transformation on regional development in the Russian Federation; the transition to the third most favourable scenario requires increased attention to the effectiveness of industrial policy measures and increased transparency and competitiveness in the distribution of the federal aid for large state projects and programs to stimulate scientific and technological developments.

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