Digitalization and its impact on regional economy transformation mechanisms

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Abstract This study aimed to identify which digital transformation areas are prioritized in regions with different levels of innovative development. Based on the analysis of statistical information presented in reports on the control indicators of regional economy transformation, the most innovative regions were distinguished. The study scrutinized the correlation of regional economic development with the presence/absence of high-tech industries in the area, as well as compared digital skills of residents of innovation clusters with residents of other regions using data structuring and the method of analytical studies. To achieve the ultimate study goal, a number of freelancers’ profiles available on freelance marketplaces was analyzed in terms of the following categories of digital skills: programming (regardless of the programming language), translation, copywriting, SEO and SMM, design, engineering services. The sample included only the profiles of individuals registered no later than 2018 who successfully completed at least three projects. An in-depth consideration of all these data allowed developing recommendations on digitalization of the regional economy, taking into account the number of inhabitants in the region and their density. As a tool for the transformation, this study proposed the four-stage Smart Region model. In sum, the carried-out investigation revealed that the benefits of digitalization are more visible in innovative regions. Correspondingly, the regions with innovative industries are characterized by higher digital skills in the field of engineering. The obtained findings can be used as a basis for management decisions by politicians and IT industry workers striving to promote the implementation of modern technologies.

Keywords Regional development · Digitalization · Public administration · Public communication · Freelance

JEL Classification R11

1 Introduction

According to the Sustainable Development Goals 2020, the creation of reliable infrastructure, promotion of comprehensive and sustainable industrialization, and implementation of innovations are among the central indicators describing the region’s development level (United Nations 2020). In this day and age, regional growth is considered within the framework of the Smart Sustainable Development model. It implicates the introduction of digital technologies, smart management, and integrated innovations together with the active involvement of the population. As such, digitalization presupposes an increase in the use of innovative technologies that create value through new products, processes, business models, and organizational structures. In view of this, the ability of regions to generate and implement the achievements of scientific and technological progress becomes one of the main factors in ensuring their global competitiveness (Khoday 2018). The novel digital economy, when coupled with mobile technologies, ubiquitous access to the Internet of Things, cloud computing, as well as a shift to big data storage and analysis, provides new ways to achieve regional productivity. These productivity plans serve as a strategic foundation for regions’ innovation.
In a regional context, digitalization actualizes various issues of regional policy, in particular, the regional labor market (including potential creation and loss of jobs), education and training, managerial innovation, sectoral development, competition, consumer protection, taxation, trade, environmental care, energy efficiency, security, privacy, and data confidentiality (United Nations Development Programme 2018). In the meantime, it should not go without mention that traditional business communication has changed dramatically during the COVID-19 pandemic. Face-to-face meetings were increasingly substituted by online interaction methods. Correspondingly, those regions where the level of digital skills was initially higher and the policies of distance work were spelled out clearly turned out to be more successful. This fact has given rise to numerous discussions on the phenomenon of digital differences across regions (digital inequality, digital divide) (Tikhonova et al. 2018; Stepanova et al. 2019).

The abundance of studies on the matter allows tracing the impact of digitalization on regional transformation over the long term (Koryagina et al. 2021). However, in doing so, a methodological problem arises—it is difficult to assess the impact of digitalization on the regions of several dissimilar countries. The national differences and macroeconomic processes may cause a dramatic influence on some territories. Thus, it can be challenging to identify common digitalization trends and deviations (Vu et al. 2020). Although digitalization is associated with increasing material inequalities (Iammarino et al. 2019), it boosts productivity not only in high-tech economy sectors but in all regions in general (Tranos et al. 2020). Concurrently, the key success factor here is workers’ skills insofar as the regions that have the most benefit from digitalization are those characterized by a highly skilled workforce (Rachinger et al. 2019; Hasbi 2020). What is more, it has been found that the benefits of digitalization are more accessible to residents of cities rather than villages.

As a result, when improving and introducing the mechanisms of the digital economy aimed at innovative development of a region, there is a need to create a science-based transformation strategy.

As noted in the Future Work Skills research report (Davies et al. 2011), the mastery of digital and soft skills should become an indispensable part of lifelong learning since the level of digital development of a country (Digital Economy and Society Index) is directly associated with their development in the population. At the same time, digital development strategies are justified at the level of individual countries and not justified for individual regions. In this regard, of particular scientific interest is the matter of working out a regional development strategy to raise the level of digitalization of the country as a whole. This can be done by determining the priority areas of funding for different regions (infrastructure, digital education, digital public services and/or high-tech national projects) as well as defining drivers of regional digital development.

The aim of this study was to identify the priority areas of regional digital transformation strategies depending on regions’ innovative development levels.

In order to achieve this goal, the following tasks were solved:

- Determine the patterns of regional digital transformations in innovative and other regions of the Russian Federation;
- Define the impact of digitalization of the economy on the socio-economic life of innovative regions;
- Develop recommendations for establishing the priority areas of funding for different regions (infrastructure, digital education, digital public services and/or high-tech national projects).

The choice of the Russian Federation as the research object is explained by the fact that its regions have different digital development levels, which makes it possible to trace the impact of digitalization on the regional economies’ transformation more accurately.

## 2 Literature review

The new paradigm of regional politics is place-based, multi-level, innovative, and geared to different types of regions (Kurushina and Petrov 2020). As noted by the European Commission (Walendowski 2011), effective regional policy is to be focused on key national/regional priorities. It should be based on the competitive advantages and potential of the region, support technological and practice-based innovation, concentrate on investment, and use reliable monitoring and evaluation systems. Notwithstanding this, the current regional growth is characterized by such a form of globalization that aims only at implementing global trends at the regional level (OECD 2018).

Today, digitalization in the context of regional development is most often referred to as the transformation of all sectors of our economy, government, and society based on the large-scale adoption of existing and emerging digital technologies (Kilpeläinen and Seppänen 2014).

The link between the region’s industrial structure, development, and implementation of digital technologies has been the subject of scientific discussions for several decades. In general, researchers concur in the opinion that there are two main approaches to defining their relationship:

- Flows of knowledge and information take place more easily over shorter distances than over longer distances,
primarily due to the benefits of closer interpersonal contacts (Kleibrink et al. 2014);
– Localized flows of knowledge and information foster localized processes of innovation, being a source of further local economic growth (Gordon and McCann 2005).

Together with this, no reliable link is observed between the region’s specialization, development of individual industrial sectors, the introduction of innovations, and the presence of various competencies among the residents of the region (Caniëls 2000).

Effective use of digital technologies in the development of regions requires adequate infrastructure, interregional cooperation, and the development of both general policies that take into account the interests of all stakeholders and flexible policies adapted to the specific needs of each sector of the economy (Simonen et al. 2016; Selezneva et al. 2021; Shestakov and Podpruzhnikov 2020). In parallel, the main factor defining the degree of development of various regions is access to high-speed Internet connection (Lin et al. 2017), which reinforces the significance of digital literacy and digital education (Interreg Europe Report 2017).

The major tools ensuring regional transformation are industrial digital platforms and innovative enterprises (Aly 2020). The digitalization of businesses located in certain regions is closely associated with a change in regional innovation policies (Randall et al. 2018). The transformation of the regional economy under the influence of digitalization is a consequence of the increased government-business cooperation in an online mode, data openness, better cybersecurity, the use of blockchain technologies, enhanced trust, creation of a common economic system, as well as changes in medicine, education, transport, security, ecology, and tourism. The digitalization of public services provokes subsequent digital transformation of the regional economy. This gives rise to the informatization of many management systems, including e-government, e-medicine, e-education, e-security, e-commerce, and e-HCS (online housing and communal services).

The beneficial impact of digitalization on society is not a topic for discussion anymore. As the central user of digital services and products, the population has received numerous possibilities through new services and developments, among which are high-speed access to the Internet and extensive information and knowledge base. Given the close link between the country’s economy, business, and residents, improving digital transformation quality remains an urgent task of this day as its solution is expected to provide new competitive advantages for the regional economy (Salemink et al. 2017).

On the other hand, the impact of the COVID-19 pandemic has proved the fundamental importance of digitalization. Using the example of many EU members, it has explicaded that a number of solutions are needed to equalize the rural–urban digital divide even at the regional level (Małkowska et al. 2021; Löfving et al. 2021) since the perception of digital innovation varies for the people of different age categories (Mikhaylova et al. 2021). This may be explained by differences in the gender and age structure of the population in urban and rural areas. The period of the beginning of economic recovery after the pandemic showed that, at the regional level, there is no relationship between the region’s development level and the indicators of innovation hubs per capita/presence of innovation hubs (European Commission-DG CONNECT 2021), digital skills of the population (ICT usage in enterprises 2021), digital public services for businesses, foreign direct investment, research and development spending, patents granted and trademarks registered, Venture Capital Investment and Availability, Fixed broadband infrastructure, and cybersecurity issues (ICT Usage in Enterprises 2021). On the other hand, at the national level, such a relationship has been identified (European Committee of the Regions 2021; Gregurec et al. 2021). In one way or another, the COVID-19 pandemic divided the regional studies into “before” and “after,” which explains the need to summarize the available data in the Literature Review.

The European Commission has developed its own strategy for the development of the digital economy in the European Union (EU) member states—Digital Agenda for Europe. In general, it is a plan for the creation of the EU’s single digital market that prioritizes the following main directions (Kilpeläinen and Seppänen 2014):

– Active participation of local authorities in building and developing regional policy;
– Integration of all EU countries’ development processes;
– Stimulation of individual regions’ growth through the formation of clusters based on innovative technologies;
– Merging regions into clusters through the system of international legal and organizational structures;
– Close collaboration between universities, research institutions, and business;
– Cross-border cooperation of regions.
– As for the central aims, the Digital Agenda provides for the following (Kilpeläinen and Seppänen 2014):

– Increased use of information and communication technologies (ICT) by residents and improving their digital skills;
– Reduction of the carbon footprint of the region;
– Providing support for research, innovation, and entrepreneurship;
– Integration of ICT into education;
– Improving the quality of healthcare and social services;
– Free access to services and resources of local governments.
At the same time, the management of local self-government bodies is responsible for the annual assessment of projects and activities related to these target areas (European Commission 2016).

Nowadays, digital technologies have an increasingly notable impact on the development of non-urban areas, allowing their residents to communicate with the authorities, benefit from novel services, and access advanced solutions (Magnusson and Hermelin 2019).

The experience of developed countries shows that dynamic improvements are observed in those regions where industrial or innovation clusters are formed (Kilpeläinen and Seppänen 2014). A good example of such an innovation cluster is the Finnish city Oulu, where Nokia was headquartered. After the bankruptcy of the Nokia Corporation, the previously created innovation cluster made it possible to overcome the crisis quickly. Their ready-made Triple Helix strategy allowed generating new jobs and attracting new companies.

Reviewing the Russian Federation as a country whose regions have different digitalization levels (Bates et al. 2019) makes it possible to argue on the following. The lack of concepts and programs for regions’ digital development is among the main problematic points of Russia. A comprehensive regional digitalization program is not developed in 45 out of 79 constituent entities of the Federation. That is, only separate regional projects are being implemented (Bates et al. 2019). The level of digitalization of the Russian economy relative to the best values of the EU countries is 83.3% in terms of infrastructure readiness, affordability, and skills (of Finland’s level); 76.3% in the use of the Internet (of Luxembourg’s level); 71.4% in political, regulatory, innovation and business environment (of the level of the United Kingdom); and 68.3% in terms of impact on the economy and society (of the level of the Netherlands) (Analytical Center under the Government of the Russian Federation 2019). On the whole, Russia shows an insufficiently developed digital infrastructure and security of digital processes, poor assistance in finding and attracting investors for information technology (IT) companies, and no state support for organizations implementing digital technologies in the regions (even in the field of high-tech business and IT) (Analytical Center under the Government of the Russian Federation 2019). Insofar as its regions differ in the level of socio-economic development, the choice of a regional development strategy that would combine the state and regional aspects in ensuring the stable development of the economic space and its regional systems and assume sustainable economic growth based on optimization of transformation processes is required. However, the current regional dynamics show that these processes have not yet yielded positive results but led to increased differentiation of regional development (Zemtsov et al. 2019), growing regional asymmetry of living conditions, expanding regional disparities in the development of productive forces, and raising disintegration of the economy and the entire economic space. Despite the implemented federal programs and regional digital development strategies, the general trend across Russian regions shows deepening of all types of regional economic disproportions (Tikhonova et al. 2018), increasing contradiction between the existing territorial and sectoral structure of the economic complex of the country and its regions, and the needs of creating a competitive and highly productive system of social production.

Even though innovation diffusion processes can be uneven and lead to such long-term challenges as economic and social inequality (Tikhonova et al. 2018), the introduction of digital economy mechanisms remains the key to increasing productivity and improving living standards in the regions. In any case, introducing digital technologies requires the transformation of regional governance and the economy based on an innovative renewal model. The disproportions in the development of individual regions of the country bring to the fore the problem of optimization of budget expenditures and differentiation of their development strategies.

3 Research methodology

3.1 Determination of the most innovative regions using the major regional economy transformation indicators

Transformation of regional economic systems is defined as a way of implementing a development strategy based on the use of a set of methods and functions that ensure effective interaction of all elements and subsystems. Aiming to fulfill strategic development guidelines, namely, the central mission and specific goals and tasks, transformation of regional economic systems takes into account the imperatives of the external environment and the level of aspirations (Startseva and Avakumova 2008). The main indicators characterizing the transformation of regional economic systems include entrepreneurship, informatization, advanced technologies, labor management, and structural reforms (Startseva and Avakumova 2008; Matskevich 2016). This approach is described in many works of contemporary Russian researchers (Matskevich 2016; Government of the Russian Federation 2019).

In connection with the above, the study focused on (1) determination of the most innovative regions of the Russian Federation in terms of the named indicators, (2) highlighting the most digitally developed regions, (3) identifying general trends in these regions, and (4) generalizing their experience to develop strategies for transforming the economy in other areas.
The investigation was carried out in several stages. At the first stage, the main trends in the regional development of the Russian Federation were determined in order to define the most innovative ones. For this, the analysis of statistical information retrieved from regional, federal, and international reports was carried out (Randers et al. 2018; World Bank Group 2018; Bates et al. 2019; Groshev and Krasnoslobodtsev 2020).

3.2 Interrelationship between regional economy transformation and innovation clusters

The second stage examined the assumption on the tendency to associate the transformation of the regional economy (both in Russia and in developed countries) with the presence or absence of high-tech industries (innovative regional clusters). To test this hypothesis, the regions of the Russian Federation were grouped according to the following indicators determined by the Spatial Development Strategy of the Russian Federation for the Period up to 2025 (Government of the Russian Federation 2019):

- Share of shipped innovative products in the total volume;
- Share of innovative enterprises in the total number;
- Share of innovative products shipped abroad in the total volume.

In order to make allowance for the size of the region, instead of absolute indicators, the shares of enterprises in the total number were evaluated. Apart from the central hypothesis, this research also tested the theory that innovative regional transformation requires an integrated approach to achieve fruitful cooperation between the government and society. Based on data presented on regional web portals and in the materials of (Bates et al. 2019), this study determined 27 innovation clusters in Russia that were united by the territorial principle and the availability of innovative industries. For this, the methods of data structuring and analysis were used.

3.3 The nature of digital skills of residents of regions with innovative clusters

The third stage compared the nature of digital skills of residents from innovative regions with those from other regions of the Russian Federation to determine the possible effect of digitalization. For this, the profiles of freelancers on such platforms as Freelancehunt.com, Free-Lance.ru, Weblancer.net, Upwork, Freelance Job, RuBrain, Dalance.ru, GlobalFreelance.ru, Tranzilla, TranslatorsAuction, and ProjectHunter were analyzed. The study considered the following categories of digital skills: programming (regardless of the programming language), translation, copywriting, SEO and SMM, design, engineering services. The requirements for inclusion in the study sample were to be registered on the platform no later than in 2018 and successfully complete at least three projects. Though, these criteria might imply several limitations. For instance, the number of freelancers representing the region could be proportional to the number of region’s residents, or profile data could be inaccurate.

Freelancing as a way of earning money is more typical for people aged under 40 (UNCTAD 2019; Zemtsov et al. 2019). Therefore, to study the impact of digitalization on the social life of innovation clusters’ residents, this research surveyed people of all ages living in the most innovative regions of the Russian Federation. The survey used a multistage sampling with a two-phase sampling design. For this, 8 clusters out of 27 were randomly chosen (Table 1). As a basis for the examination, the total number of people living in the regions under consideration was taken. The selection of respondents was carried out by sending invitations to social networks (Facebook, VK). The survey was carried out using Google Forms. Invitations to be involved were sent

| Location                 | Cluster (based on data retrieved from Bates et al. (2019))          | Total number of respondents | Number of respondents agreed to take the survey |
|--------------------------|---------------------------------------------------------------------|----------------------------|-----------------------------------------------|
| Altai Territory          | Biopharma Cluster                                                   | 258                        | 256                                           |
| Arkhangelsk Region       | Shipbuilding Innovation Territorial Cluster                         | 187                        | 186                                           |
| Kaluga Region            | Cluster of Pharmaceutics, Biotechnology and Biomedicine             | 295                        | 295                                           |
| Republic of Udmurtia     | Udmurt Machine-Building Cluster                                     | 271                        | 271                                           |
| Perm Territory           | Innovative Territorial Rocket Engine Cluster Technopolis New Star  | 291                        | 291                                           |
| Moscow Region            | Cluster of Nuclear Physics and Nanotechnology in Dubna              | 364                        | 363                                           |
| Tomsk Region             | Titanium Cluster                                                    | 314                        | 312                                           |
| Ulyanovsk Region         | Nuclear Innovation Cluster of Dimitrovgrad                          | 311                        | 311                                           |
| Total                    |                                                                     | 2296                       | 2290                                          |
to those people who indicated one of the selected regions in their profiles.

The chosen approach also imposes some limitations on the research process. In particular, there is a possibility that the actual place of residence fails to coincide with the declared one. In the meantime, respondents from Moscow and St. Petersburg were not invited to take the survey since these cities lead in digital technologies (Bates et al. 2019), which can distort the study results. The survey was completely anonymous and voluntary. It was conducted in August 2020 and involved 2296 people, five of whom refused to participate (0.3%). The questionnaire contained the following five questions:

1. What are the main digitalization tools you use?
2. What are the basic socio-cultural practices typical for your region?
3. Who initiates these socio-cultural practices—authorities or the population?
4. How much do you trust various public organizations, associations, and similar structures? Are you a member of any of them?
5. What challenges does the region face while implementing digital projects?

Each question could have several answers. The study aimed to define the dominating group of respondents.

3.4 Digitalization of the regional economy: recommendations and suggestions

The final study stage aggregated all the previous data to develop recommendations on priority financing areas for different regions (infrastructure, digital education, digital public services and/or high-tech national projects).

4 Results

4.1 Determination of the most innovative regions using the main indicators characterizing regional economy transformation

At the first research stage, already implemented regional digital projects were analyzed using data of Bates et al. (2019). By means of a thorough investigation, the very process of any project’s implementation was noted to be carried out within the framework of the national program Digital Economy of the Russian Federation. Furthermore, it was found that most digitalization-related projects are connected with the sphere of urban governance (32 landmark projects). More specifically, these are, for example, the Electronic Budget project in the Bryansk Region; the Unified Regional Data Management System in the Leningrad Region; projects on the implementation of regional information systems (RIS PC Purchases) in the field of procurement of goods, works, and services to meet the needs of the state; projects on the implementation of an automated system for managing the financial and economic activity of the Irkutsk Region and state institutions of the Irkutsk region (AIS FHD); e-government services of the Republic of Buryatia. Significantly fewer digital projects were launched in education and healthcare: only 11 of them were noted in the field of education (e.g., the automated system for managing the education sector of the Krasnodar Territory) and 12—in healthcare (e.g., clinical decision support system (CDSS)) in the Yamalo-Nenets Autonomous District.

The classification of regions in accordance with these indicators was carried out following the methodology of the Federal State Statistics Service of the Russian Federation (Federal State Statistics Service 2018). Table 2 displays the first 20 regions showing the way in innovative development (in terms of the analyzed indicators).

In such a manner, it can be seen that the leaders in innovative development are predominantly regions with innovation clusters. Apart from this, based on the analysis and generalization of statistical information presented on the regional portals of the constituent entities of the Russian Federation, the following trends were revealed:

- Foremost attention in regions with large population size is paid to the development of interaction between regional authorities and society, which is manifested in the areas of projects’ implementation (e-reception, e-government, e-procurement, e-administration);
- Regions with a low population density set the focus on projects related to education and/or healthcare; these regions have difficulties in access to the appropriate infrastructure, which is one of the main conditions for effective digitalization (Groshev and Krasnoslobodtsev 2020);
- The most developed regions in the field of industrial production are characterized by the presence of comprehensive digital development programs.

4.2 Relationship between the transformation of the regional economy and the availability of innovation clusters

At this stage, it was established that 27 innovation clusters have innovative development programs for the digital sphere (e.g., information-oriented society. Regional Digital Economic Development Program).

The issue of the innovative orientation in the regions’ growth is associated primarily with the development of innovative strategies, formation of a balanced set of policies,
and creation of an extensive innovative infrastructure to ensure competitiveness. In this regard, it seems appropriate to review the tasks, conditions, levers, and mechanisms, which must be taken into account when creating a model of innovative regional development.

The chief priority areas for all clusters are big data, industrial Internet, wireless technologies, and virtual and augmented reality. Most often, they are used in public services and management, housing and communal services, personnel training and education, urban environment and transport management.

It is also important to note that the top 20 regions considered in this study occupy high places in the Digital Russia rating (Bates et al. 2019), which implies their well-developed infrastructure. In contrast, the regions where a development program is not introduced, as a rule, experience considerable difficulties with digital infrastructure availability caused by the large territory, harsh geographic conditions, or a relatively small population size.

### 4.3 Analysis of the nature of digital skills of residents of regions with innovative clusters

At the third stage of the research, 1341 profiles of individuals looking for a job on freelancing platforms were analyzed. It was found that, regardless of the region, the most popular categories of digital skills are programming, translation, copywriting, SEO, and SMM. Meanwhile, in the regions with innovation clusters, a significant share of all orders (37%) is connected with design and engineering services.

Therefore, one can assume that the availability of innovative enterprises is directly related to the development of digital skills in the field of engineering (engineering planning and design, 3D modeling, finite element analysis). However, it is worth pointing out that these skills are the most cited by 35–45-year-olds.

The third stage also considered the impact of the economy’s digitalization on the social and economic life of people living in regions with innovation clusters. For this, residents of different ages were interviewed (Table 3).

The survey results indicate that, in general, respondents recognize the introduction of digital technologies into the regional economy as a positive phenomenon. The central focus was defined to be set on the means of managing the urban economy, transport system, and healthcare. In addition to this, the survey allowed outlining the following tendencies in innovative regions’ socio-cultural sphere:

- Volunteering is one of the top-priority socio-cultural practices; however, its implementation is often disorganized and accompanied by various foundations’ fraudulent actions due to the digital communication growth among the population;
– High level of volunteering activity among all population segments, especially young people;
– High level of informatization and computerization as a sign of the formation of the prerequisites for creating an information-oriented society.

Within the framework of this study, the results obtained demonstrate the readiness of innovative regions’ residents to self-organize in order to improve the efficiency of regional management. Besides, these data make it possible to put forward a hypothesis that an enhancement in the level of digital skills is associated with an increase in the population’s involvement in public life.

4.4 Development of recommendations for the digitalization of the regional economy through the Smart Region model

The last study stage was directed at providing recommendations for the digitalization of the regional economy with reference to the number of their residents and the population density (Table 4).

The use of the proposed recommendations at the level of regions and individual areas would make it possible to facilitate the development of regional digital transformation programs by implementing mechanisms for

| Table 3 | Generalized survey results |
|---|---|---|
| **What are the main digitalization tools you use?** | **Number of respondents** | **Dominating group of respondents** | **Dominating cluster** |
| E-administration, e-petitions, e-transport, e-healthcare, public transport arrival board, LED lighting applications | 100% | All respondents | All clusters |
| **What are the basic socio-cultural practices typical for your region?** | **Volunteering** | **Workshops, practical courses, presentations** | **Exhibitions, alternative and informal art** | **Other** |
| | 2022 (88%) | 1817 (79%) | 2015 (88%) | 11 (0.5%) |
| | All respondents | All respondents | All respondents | All respondents |
| **Who initiates these socio-cultural practices—authorities or the population?** | **Authorities** | **Population** |
| | 114 (5%) | 2177 (95%) |
| | All respondents | All respondents |
| **How much do you trust various public organizations, associations, and similar structures? Are you a member of any of them?** | **I do not trust any organizations** | **I rather trust informal organizations** | **I rather trust governmental organizations** | **Do not know/No answer** |
| | 344 (15%) | 573 (25%) | 389 (17%) | 1306 (57%) |
| | All respondents | Men and women aged 20–30 | Women aged 30–60, men aged 45+ | All respondents |
| **What challenges the region faces while implementing digital projects?** | **Poor infrastructure in rural areas, which reduces the opportunities for their residents** | **Officials’ opposition to implementing digital programs** | **Difficulties in the use of digital solutions** | **Do not know/No answer** |
| | 1695 (74%) | 389 (17%) | 10 (0.5%) | 197 (8.6%) |
| | All respondents | All respondents | All respondents | All respondents |

| Table 4 | Recommendations for digitalization of regions, by the population size and density |
|---|---|---|---|
| **Population size/density** | **High density** | **Low density** |
| Large population size | Improve and support basic infrastructure | Introduce Smart City technologies, promote the formation of innovative industries, increase the digital literacy of residents, especially those of retirement age |
| Small population size | Introduce Smart City technologies, promote the formation of innovative industries, improve the digital literacy of the population | Introduce Smart Village technologies, work on basic infrastructure to develop digital projects in the future, design a comprehensive digitalization program for the region, improve the digital literacy of the population |
eliminating the digital divide between territories, economic activity types, and social institutions.

The current territorial management in Russian regions is characterized by uncertainties in organizational structures and management bodies. Furthermore, it possesses significant interregional disproportions in the state of information and communication infrastructure, socio-economic development, financial potential, and housing and communal services. In light of the foregoing, the authors of the present work have developed a plan of measures focused on the strategic transition of regions’ outdated management systems to the Smart model (Fig. 1).

The analysis of the digitalization effect on the regions’ innovativeness made it possible to identify and systematize the main problems that negatively influence the process of regions’ transformation. They include the lack of physical
innovation infrastructure (inadequate quality, coverage, and access to the main communication means, particularly the Internet; lack of innovative enterprises) and insufficiently developed cooperation between the authorities and society. Consequently, it can be concluded that these indicators are among the primary reasons for disproportions in the development of regions and individual territories. It is their development level that determines the quality of digital skills of the population and the degree of its involvement in public life.

5 Discussion

The investigation results found clear support for the view that the infrastructure of the region plays a key role not only in the development of the population’s digital skills but also in determining their nature. This study was the first to establish that the presence of innovative industries in the region is associated with the possession of digital skills in the field of engineering (engineering planning and design, 3D modeling, finite element analysis). In general, the findings obtained are consistent with the results of Russian and international researchers (Shevchuk and Strebkov 2015). Nevertheless, the category of digital skills under the given context was not previously described in the scientific literature.

In contrast to other countries, where the state has a leading role in shaping the digital economy as a whole (EU4Digital 2021; European Commission 2021), for Russian regions, the role of the state in this process is not so significant. Joining the international online business is not an option for the Russian population but a necessity as it will lead to a gradual transition to digital governance. Tight international relations make the development of digital infrastructure inevitable. The peculiarity of digital development of innovative Russian regions is that individual users and businesses are far ahead of the state and industry. Here, small and medium-sized businesses are already using ICT and place a premium on digital methods to promote their services, while the state and big industries are lagging behind.

The main influence digitalization had on the social life of the most innovative regions was improved self-organization and increased volunteering among residents of all ages. It was noted that self-organizing activities in a territorial cluster take the form of various voluntary associations. These associations are independent of public authorities but engaged in making and implementing decisions on local significance matters through cooperation between citizens, the government, and business. Around the same time, volunteering acts as a mechanism for the preservation and revival of human and social resources—crucial factors for the development of a territorial community (Foray et al. 2009). Strengthening and development of social interaction, cooperation, and mutual trust in the cluster promote an increase in the overall confidence in the local government. It establishes conditions for overcoming dissatisfaction with the “government-person” and “government-society” relations, thereby ensuring an effective dialogue by means of referendums, public hearings, and public opinion polls (Foray et al. 2009).

The transformation of territorial economic systems requires strengthening state—business—society relationships both at the national and regional levels. On the other hand, one cannot overemphasize the necessity to improve collaboration between individual production sector representatives to enhance general economic growth. Since innovative development is carried out against the backdrop of the spread of integration processes and the mobility of intellectual labor representatives, cooperation between various industries, enterprises, and territories is paramount.

The modern paradigm of regional management (Kurushina and Petrov 2020) sets its focal point on local specifics. It suggests making the most of local institutions, improving the availability of goods, services, information, and promoting innovation and entrepreneurship. Within this paradigm, the concept of smart specialization arose, which provides for both horizontal interaction (between regional, industrial, and research structures) and vertical interaction (between regional, state, and supranational bodies) (Vanthillo and Verhetsel 2012).

In the present stage of ubiquitous transformation and digitalization of the economy and society, the Smart Region model should become the basis for the formation of effective territorial communities capable of sustainable development. Its realization is possible only in the case of comprehensive state support of accelerated digitalization of the economy and public administration in all areas. The government is to form effective legal and financial (including tax) instruments and mechanisms to stimulate the development of innovative production, infrastructure, communication, and ways of training personnel. It is under such conditions, popularization of the transition to digital technologies, digital production, digital business, and digital society should occur.

The degree of digitization of the regions of the Russian Federation is influenced by inter-regional differentiation, which may vary in the center, i.e., developed territories with high incomes, and the periphery—less developed territories with low incomes. The economy of Russia is characterized by unevenness in the level of average wages and unemployment across regions. In other words, a worker’s place of residence is a key factor in labor supply and, respectively, in the level of wages and the presence/absence of relevant digital skills (Zhang and Li 2018; Zhang et al. 2021). Although the main changes in the labor market are caused by digitalization, the Internet usage scenarios in the regions are different. Nevertheless, the problem here is not in the lack of need,
but in the lack of opportunity for the population to develop certain digital skills.

The EU experience shows that it is advisable to use the Smart specialization strategy to succeed in developing innovation clusters. Smart specialization is applied in the EU at all levels to improve competitiveness and sustainability. It is supposed to encourage investment in areas that should complement the region’s production assets to create its internal competitive advantages (Zeibote et al. 2019). The main principle of specialization search is to identify points of potential for the effective use of general-purpose technologies in promising sectors.

The advantage of the Smart specialization approach is in creating prerequisites for concentrating efforts and resources of local authorities and businesses on innovative activity in relevant areas. Thus, the central aim of Smart specialization is to increase the competitiveness of the economy at the regional level and facilitate the development of businesses applying innovations (most often small and medium-sized). Local communities face ample opportunities owing to proper information support, building active cooperation with adjacent communities, developing the last-mile infrastructure, and optimizing the labor potential (through vocational training). In the event of competent structuring of these impacts, the region can modify its specialization in accordance with the Smart strategy determined based on the resource status quo.

To determine the differences between regions in the implementation of digitalization mechanisms, a system of calculated indices (Wei 2020), correlation analysis (Zemtsov et al. 2019), a combination of statistical methods (Tikhonova et al. 2018; Tolstykh et al. 2018), or the definition of key indicators can be used (Startseva and Avakumova 2008; Matskevich 2016). The current study took advantage directly of the principal indicators characterizing the transformation of the regional economy (entrepreneurship, informatization, new technologies, labor organization, and structural transformation). This approach is quite popular and can also be found in other works of modern Russian researchers (Startseva and Avakumova 2008; Matskevich 2016).

6 Conclusions

Within the framework of this article, the issue of transformation of the regional economy in the context of digitalization was studied. For the sake of a grounded and thorough analysis, the paper considered the main infrastructural factors, the presence/absence of strategies for the regional development, residents’ digital literacy and their communication with one another and the authorities.

The main idea of the study was to identify the central factors that determine the innovativeness of the region and generalize the available experience in this field to develop strategies for transforming the regional economy. For this, the study scrutinized the statistical information presented in regional, federal, and international analytical and statistical reports published in Russia and abroad. As a result, the study revealed that innovation development leaders are represented by the regions with innovation clusters.

The analysis of statistical information presented on the web portals of the constituent entities of the Russian Federation allowed identifying the following trends characterizing the asymmetry of digitalization:

- In regions with a large number of people, principal attention is given to the improvement of interaction between regional authorities and society, which is clearly shown by the areas of changes (e-reception, e-government, e-procurement, e-administration);
- Areas with a low population density concentrate directly on projects related to education and healthcare; such regions are characterized by complicated access to relevant infrastructure, which is among the foremost requirements for effective digital transformation;
- The most industrially advanced regions have the most sophisticated digital development programs.

It was established that the main condition for implementing digital projects is the availability of infrastructure, whereas innovative projects require innovative enterprises in the region. These factors enable the region’s residents to realize their digital skills more fully, as well as self-organize to achieve better local management. The study confirmed that the advantages of digitalization are more pronounced in the innovative regions of the Russian Federation. Along with this, it was discovered that innovative industries in the region and digital skills in engineering are in direct dependence on each other. In such a manner, a necessary precondition for these skills’ acquisition is the presence of innovative companies, which, in turn, is impossible without a comprehensive regional development strategy.

As a consequence of the performed investigation, the paper provided practical recommendations to promote the regions’ digital development with reference to the number of their residents and the population density. In this vein, the territories with a high population density and a significant number of residents are advised to improve and support basic infrastructure. For regions with a low number of residents and a high population density, it is recommended to introduce Smart City technologies, promote the creation of innovative industries, and increase residents’ digital literacy. What concerns regions with a small number of people and low population density, they are proposed to develop a comprehensive digitalization plan that would include all the suggestions given above. The foremost goal of these
strategies should be the creation of industries implementing up-to-the-minute technological modes and focusing on the domestic and foreign markets with world-class high-tech products. These actions are predicted to guarantee the competitive advantages of the Russian economy in promising market sectors.

The practical value of the article stems from the fact that the proposed recommendations can serve as a theoretical basis for creating partnership relations between the authorities and society in an attempt to develop the digital regional economy. It can serve as a foundation for research on the impact of digitalization on the regional economy as well as for the development of new related improvement methods or models. Further studies may consider the implementation of the recommendations proposed in this paper for regions that are not innovation clusters.

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