Internet diffusion and interregional digital divide in Russia: trends, factors, and the influence of the pandemic

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INTERNET DIFFUSION AND INTERREGIONAL DIGITAL DIVIDE IN RUSSIA: TRENDS, FACTORS, AND THE INFLUENCE OF THE PANDEMIC

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The demand for digital technologies has been growing due to a shift in the technological and economic paradigm. The need for online services has increased since the beginning of the COVID pandemic. There are significant disparities between Russian regions in the digital technology accessibility and the development of computer skills. In 2020, the Internet diffused rapidly in most regions, although previously, there had been a slowdown. As markets got saturated with digital services, the digital divide between Russian regions narrowed. Overall, the Internet use patterns are consistent with those of the spatial diffusion of innovations. Amongst the leaders, there are regions home to the largest agglomerations and northern territories of Russia, whereas those having a high proportion of rural population lag behind. Coastal and border regions (St. Petersburg, the Kaliningrad region, Karelia, Primorsky Krai, etc.) have better access to the Internet due to their proximity to the centres of technological innovations as well as the high intensity of external relations. Leading regions have an impact on their neighbours through spatial diffusion. Econometrically, access to the Internet depends on income, the average age and level of education, and its use depends on the business climate and Internet accessibility factors. Regional markets are gradually getting more saturated with digital services and technologies. The difference between regions in terms of access to the Internet is twofold, whereas, in terms of digital technology use, the gap is manifold. In many regions, the share of online commerce, which became the driver of economic development during the lockdown, is minimal. Based on the results of the study, several recommendations have been formulated.

Keywords:
ICR, digital technologies, digital economy, Russian regions, diffusion of innovations, online trade, pandemic, econometric modeling, system of equations

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Introduction

Over the past few decades, there has been an active diffusion of information and communication technologies (ICT),[1] in particular, the Internet, into all spheres of human activity. The related changes in recent years in technologies, production methods, and in the interaction of economic agents are commonly called *digitalization* [1]. This is a technological revolution, though some authors also talk about a new industrial revolution [2]. The introduction of digital technologies and the spread of the Internet economy provided up to a third of the economic growth in Sweden, Germany, Great Britain and other developed countries [3]. During 2010—2017, the digital sector of the Russian economy grew by 17 %, almost twice outpacing GDP growth [4], and the costs of developing the digital economy reached 3.7 % of GDP by 2019 (in developed countries — 2—3 times higher) [5]. An increase in the number of broadband Internet access subscribers by 1 % on average leads to a 0.1 % increase in GRP in the Russian regions, and an increase in the intensity of use leads to an additional increase in output by 0.05 % [6]. Thus, the spread of the Internet is a significant factor of economic growth.

In 2021, the share of Internet users exceeded 59 % of the world's population, which is higher, for example, than the urbanization rate. The highest values are typical of the countries of Northern Europe, including the Baltic region, North America, and South Korea (more than 80 %), and the lowest values are in the Central African countries (in some countries — less than 10 %). In Russia, the value is about 77 % [5], but there are significant spatial differences [7].

The spread (diffusion) of technologies is spatially uneven, and the global risk of growing digital inequality is highly probable [8]. Differences between countries, regions, and households in access to ICT and the ability to use them grew. This limits the opportunities of a part of society to participate in modern economic processes and reduces access to modern distance education and telemedicine [9], and limits the ability of businesses to enter new markets, etc. In Russia, about 81 % of urban residents had access to high-speed Internet, and in rural areas only 65.8 %.[2] These differences aggravated after the introduction of quarantine measures during the pandemic [10].

[1] In the article, *digital technologies* are understood as a set of software and hardware tools associated with electronic computing and data conversion, which are used to store and transmit large amounts of data, provide high-speed calculations. The related concept of «information and communication technologies» (ICT) is used in a broader context — it is a set of software and hardware tools, processes and methods combined into one chain that provides the collection, storage, processing, analysis and dissemination of information. ICT can be based not only on digital, but also on analogue means of information processing. In general, both concepts are used in the article when describing the process of distribution and use of the *Internet* — a worldwide computer network designed to store, process and transmit information based on digital technologies [1].

[2] *Selective* federal statistical observation on the use of information technologies and information and telecommunication networks by the population, 2021, *Rosstat,* URL: https://gks.ru/free_doc/new_site/business/it/ikt20/index.html (accessed 15.07.2021).

The introduction of digital technologies made it possible to carry out many daily processes during the pandemic: distance learning, electronic public services, the delivery of goods, etc. Digital technologies have also become one of the factors for business adaptation due to the expansion of online commerce [11]. In the world and in Russia, the need for online services and 'unmanned' technologies has increased [12]. At the same time, the rate of new technologies diffusion in the world had been growing even before the COVID crisis [13; 14]. Earlier it took decades for television to spread, whereas in 2020, new Internet services, video conferencing programmes (Zoom and others) were mastered by most users in months. Various forms of remote work have become ubiquitous. So, before the pandemic, only 2 % of respondents worked remotely. In May 2020, 16 % of respondents partially or completely switched to this work format,[3] in Moscow and St. Petersburg — 29 %, and in rural areas — less than 10 % of respondents.

The introduction of digital technologies is considered by the governments of many countries both as a tool for anti-crisis measures and as a factor of long-term development. The Government of the Russian Federation included measures aimed at transferring public services to an online format in the action plan for economic recovery in 2020—2021, and one of the national development goals[4] is to increase the share of households with broadband access to the Internet up to 97 % (in 2020 — about 77 %). However, there are significant differences between regions, requiring a regional decomposition of the national goal. This requires a deeper analysis of the underlying factors of Internet diffusion.

In 2022, amid breaking global production chains, worsening trade relations and other restrictions, the role of digital technologies is increasing in Russia. Online stores (for example, Ozon, Wildberries, Yandex.Market, etc.) have become more popular, providing the import of goods (including parallel imports) and their delivery throughout the country. There is a record growth in online commerce.[5]

The aim of this study is to describe general spatial trends and identify significant factors that determine the differences in the distribution and use of the Internet in the Russian regions over the past decade. The novelty of the work lies in conducting an econometric analysis based on regional data over a long period of time, taking into account the mutual influence of various groups of technologies at different levels of the digital divide. Particular attention is paid to changes that occurred during the pandemic.

[3] Russian Public Opinion Research Centre: the number of Russians working remotely during the pandemic increased eight *times*.

[4] Decree of the President of the Russian Federation of July 21, 2020 № 474 "On the National Development Goals of the Russian Federation for the period up to 2030", 2020, President of Russia, URL: http://www.kremlin.ru/acts/bank/45726 (accessed 14.11.2021).

[5] Online sales in Russia grew by almost 1.5 times over the year — up to 2.3 trillion rubles, 2022, *Vedomosti,* URL: https://www.vedomosti.ru/business/articles/2022/08/10/935478-onlain-prodazhi-rossii-virosli (accessed 14.08.2022).

The article presents a brief overview of the main patterns of technology diffusion identified in the literature to substantiate the hypotheses for empirical analysis. Next, three forms of the digital divide in the Russian regions are considered, their interconnections are assessed, and individual factors are identified. Finally, conclusions and some recommendations are given.

Literature review

The spread of new technologies, including digital ones, between countries and regions, generally follows the classical laws of innovation diffusion [15—17]. The world has accumulated a lot of experience in such studies (see a detailed review in [18]).

Society can be divided into several groups, depending on the speed of accepting a new technology (according to Rogers [15]): innovators, early followers, early majority, and conservatives. Initially, the spread of new technology reproduces existing patterns of socioeconomic inequality and may reinforce them. If we consider the country as a single community, then similar patterns can be seen between regions [17; 18]. Innovative regions in Russia usually include global cities, Moscow and St. Petersburg, early adopters are the Moscow region and the largest agglomerations. Lagging behind are underdeveloped regions of the North Caucasus, South Siberia, and rural areas. At the same time, the diffusion rate of a new technology depends on the innovation-geographical position of a region, that is, proximity to the source of innovation [10]. In innovative regions, the proportion of potential users is higher, diffusion begins earlier, and spreads faster. Proximity to the innovation core determines the special position of coastal and some border regions [18; 19], where new technologies may arrive earlier. The density of contacts and communications with the core is higher in them, as for example, between the Russian North-Western regions and the countries of Northern Europe.

When describing the spatial patterns of diffusion, three main models are distinguished [18; 20]: areal (or neighbourhood), cascade (or hierarchical) and network (chain). In the first case, the diffusion firstly goes from the core to the nearest settlements, in the second it is going according to the hierarchy of cities, and in the third – according to the network principle. It is also possible to single out a directive form of distribution, when the state determines the directions and ways of introducing technology, for example, when distributing electronic public services.

The heterogeneity of the socio-economic space and the uneven distribution of ICT have caused the problem *of digital inequality*, or *digital divide*[6] — *differences in access to ICT infrastructure, skills and goals of using digital technologies. There are three main levels:*

[6] In our study, we use both concepts as synonymous. Although the "gap" is often understood as high and growing inequality.

1. Internet access: availability of physical infrastructure and accessibility in terms of connection costs and subscription fees [21; 22];

2. The ability of residents to use digital technologies: digital literacy, competencies, the ability to order goods, services, etc. [23];

3. The ability of residents and entrepreneurs to use the Internet for commercial purposes: placing online orders, Internet banking, electronic commerce (e-commerce), etc. [24; 25].

Most of the studies are devoted to one of these levels [26]. The high availability of technology may not affect the level of its use [23; 26]. Accordingly, the availability of the Internet in some settlements may not contribute to economic growth or better quality of life, although the state is striving for this by introducing various programmes to support digitalization.

A person's actions regarding a new technology depend both on personal characteristics (age, gender, experience, propensity to take risks, etc.) and on environmental factors, for instance, the culture of the local community [22; 27; 28]. Therefore, a large set of sociological [29] and statistical methods can be used to study these processes.

In previous econometric studies (Table 1), most of the factors are various characteristics of the spread of digital technologies, for example, the availability of different plug channels and the cost of connection. One of the basic factors of digital inequality is the differences in the level of socio-economic development between regions, measured by GRP per capita. The problem is that digital technologies are also capable of influencing GRP, as it was mentioned above. Therefore, when building econometric models, various methods are used to avoid such endogeneity between variables: the generalized method of moments (the Arellano-Bond approach) or the two-step least squares method (2SLS).

Table 1

Overview of variables and methods for researching the digital divide

The authors	Dependent variable estimating the digital divide	Independent variables, factors (direction of influence)	Calculation method
Grosso, 2007 [30]	Number of broadband subscribers	Availability of different connection channels (+), GDP per capita (+)	Generalized Least Squares for Panel Data (Panel EGLS)
Lin, Wu, 2013 [31]	Number of broadband subscribers per capita	Availability of different connection channels (+), connection cost (–)	Generalized Method of Moments (GMM)
Haucap et. al., 2016 [32]	Share of households with broadband access, %	Connection cost (–), variety of tariffs (+), household income (+), high level of education (+)	Two-Step Least Squares (2 SLS)

The end of Table 1

The authors	Dependent variable estimating the digital divide	Independent variables, factors (direction of influence)	Calculation method
Lucendo-Monedero et al., 2019 [33]	Household and Individual Digital Development Index	Influence of neighbouring regions (+)	Moran's index I
Szeles, 2018 [34]	Share of internet and e-commerce users, %	High level of education (+), spending on research and development (+), economic growth (+/–)	Multilevel Modeling (MLM)
Vicente, Lopez, 2011 [35]	1. Share of households with access to the Internet, %. 2. Share of households with broadband connection, %. 3. Share of people who regularly use the Internet, %. 4. Share of people who ordered goods or services online, %	GDP per capita (+), high level of education (+), age (–/+), employment in services (+)	Factor analysis for dependent variables
Pick, Sarkar, Johnson, 2015 [36]	1. Share of households with a desktop computer or laptop, %. 2. Share of the total number of households with broadband Internet access, %. 3. Share of people aged 18 years and older living in households with only cordless phones, %. 4. Number of subscribers of mobile wireless high-speed devices per capita	Influence of neighbouring regions (+), high level of education (+/–), Putnam social capital index (+)	Methods: cluster analysis (k-means method), Moran's index I, OLS
Pick, Sarkar, Parrish, 2021 [37]		Business climate (+), high level of education (+/–), human development index (+),	Double step OLS (2 SLS)

Source: Compiled by the authors on the basis of the studies cited.

Household income, the size of a city, and population density influence Internet availability, thus determining the potential market for Internet providers [35]. The ability to use the Internet depends on income, the level of education and the age of potential users [36]. But the ability to make a profit using the Internet depends on business climate, including competition between companies in the online sector [37]. Some works [33; 36] noted the influence of neighbouring regions.

Hypotheses, data and research methodology

Patterns identified abroad may not always be directly applicable to the Russian regions. There are several constraining factors for the development of ICT in Russia, including relatively low household income, underdeveloped infrastructure in rural areas, and the weak demand for new technologies by businesses in non-competitive markets [18; 38; 39]. When analyzing domestic data, econometric methods are practically not used. Usually, one year and one technology were considered.

Based on our review of the literature and recent trends, we tested several hypotheses:

1. Differences between the Russian regions in the level of Internet penetration generally correspond to the spatial features and innovation diffusion factors identified in the literature (Table 2). The digital divide is affected by differences in income, education level, business development, as well as geographical characteristics of the region: proximity to a large city (hierarchical diffusion) and the source of innovation (neighborhood diffusion). The accessibility of the Internet affects its use and the development of online commerce, which has not been analyzed before.

Table 2

Indicators and drivers of the digital divide

Variable	Description	Possible direction of influence
Dependent variables		
intern1	Share of households with access to the Internet from a home computer, %	
intern2	Share of households with broadband Internet access, %	
intern3	Share of the population that are active Internet users, %	
intern4	Share of the population who used the Internet to order goods and/or services, %	
intern5	Share of online sales in total retail turnover, %	
Financial accessibility of the Internet (income of residents and cost of services)		
price	The ratio of the subscription fee for Internet access to the average income of the population, %	–
income	The ratio of nominal cash income, taking into account interregional prices, to the subsistence minimum, %	+
market_inc	The amount of cash income of all residents minus the subsistence level, billion rubles	+
Characteristics of human capital		
heurb	Share of employed citizens with higher education in the total population of a region, %	+

The end of Table 2

Variable	Description	Possible direction of influence
old	Percentage of permanent population older than working age (> 59 for men; > 54 for women), %	–
Institutional conditions (business climate and business development)		
SME	Number of small enterprises, including micro, per workforce, units	+
inform	Share of employed in the informal sector, %	–
Economic and geographical characteristics of diffusion of innovations		
centre	Population of a central city of a region, thousand people	+
Internet	Average level of Internet penetration among households in neighbouring regions	+

Source: Compiled by the authors on the basis of the literature review.

2. In 2020, the spread of digital technologies in the Russian regions was accelerated by the growing demand for remote services during the COVID pandemic [14]. This thesis is widely analyzed in the literature, however, the maximum spread rates of these technologies could have been achieved earlier, since more than half of households use the Internet. According to the theory of diffusion of innovations, in this case, the rate of diffusion should decrease.

3. The interregional digital divide in Russia has grown in 2020 due to the widening gap between rich and poor regions. However, according to the theory of spatial diffusion, inequality could decrease at the final stages of diffusion.

To confirm the hypotheses, the spatial differentiation and dynamics of indicators for the last available period of 2014—2020 were considered in detail based on data provided by Rosstat[7] (Table 2). For the first time in Russia, three levels of interregional digital inequality are analyzed in detail. Several indicators were used for purposes. The first level (*access to the Internet infrastructure*) is measured through the share of households having a computer (*intern1)* [36] and

[7] Selective federal statistical observation on the use of information technology by the population, 2020, *Rosstat,* URL: https://www.gks.ru/free_doc/new_site/business/it/ikt20/index.html (accessed 15.07.2021). Since the results of sample surveys of the population were used, the interannual variation of indicators is high in certain regions, especially less developed ones. There are also certain doubts about the correctness of the statistical sample for the latter in conditions of weak civilian control. Distortions may be caused by a sample bias towards more educated urban residents, while the majority of residents may not be able or willing to participate in surveys. For example, the proportion of households with high-speed Internet is high in Tyva (Fig. 1). But there is no other source of data for a long period of time for all regions in Russia.

broadband Internet access *(intern2*) [31]. The second level (the *ability to use the Internet*) is measured as the intensity of using the Internet (at least once a week) (*intern3)* [35], as well as ordering goods and/or services online *(intern4*)[8] [34]. For the third level (the *ability to use the Internet for commercial purposes*), we chose the share of the online sector in trade"[9] *(intern5*), which was not previously used for these purposes. The latter indicator is not directly related to the population, but indirectly reflects the ability of residents and entrepreneurs (owners of online stores) to use the Internet for profit. No other indicators relevant to our purposes were found in the statistics available. In addition, the relevance of studying the processes of the spread of online commerce has increased dramatically in recent years.

To test the first hypothesis, econometric calculations were carried out to identify the determinants of the digital divide (Table 2). We proposed and applied several indicators to assess each of the main factors identified in the literature: the financial affordability of the Internet [31; 32], user characteristics [34—36], institutional conditions [37], and economic and geographical features of regions [18; 19; 33; 36]. One model used weakly correlated measures to avoid multicollinearity. Only significant variables were selected for the final model. It was the first time a system of simultaneous equations estimated by a two-step least squares method has been used on Russian data. This enabled us to avoid the problem of the correlation of endogenous variables and reduce the bias of the estimates.

It is also the first time estimates of changes in the interregional digital divide under the influence of the pandemic and in previous years have been made. For the purposes of verification, several indicators were used to characterize the degree of dispersion of the data array: the coefficient of variation, the ratio of the maximum value to the minimum, and the Theil index. The dependence of the growth rate of the indicator on its base value in the previous year was assessed to test the hypothesis about the divergence of values between regions.

Research results

The geography of the digital divide in Russia

The first type of digital inequality was assessed through access to ICT infrastructure. The basis for the sustainable use of the Internet is broadband access technologies: fibre optic cables, 4G, etc. In 2020, 77 % of households in Russia had access to fast Internet (Fig. 1).

[8] In some cases, the indicator can also be used to measure the third level of inequality, since the orders of the population and the placement of goods by business are highly correlated.

[9] Share of online sales in total retail turnover, 2022, *EMISS,* URL: https://www.fedstat.ru/indicator/50236 (accessed 15.07.2022).

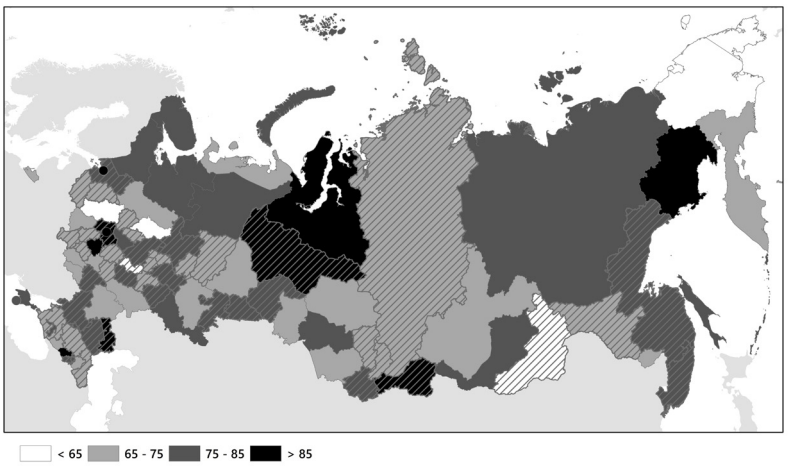

Fig. 1. Share of households with broadband Internet access in 2020, %

Hatching indicates regions where the value of the indicator increased in 2020, and the growth rate in 2020 was higher than in 2019.

The share of households with broadband Internet access is higher in the largest agglomerations with increased demand for relevant technologies and high competition among providers that reduces the price of the Internet: Moscow, St. Petersburg (87 %), Tyumen, Kazan, Samara, Voronezh, in their neighbouring regions (Tula, Moscow, Leningrad regions), as well as in Russia's north (YaNAO, KhMAO, Magadan, Murmansk regions, Karelia), where communication services are in demand because of spatial isolation, as well as the need to interact with the 'mainland'. In addition, northern regions have high household incomes and are characterized by a high degree of urbanization. The share of households with broadband Internet access is also higher in coastal regions: the Primorsky krai, Khabarovsk, Crimea, Rostov, Sakhalin and Leningrad Regions due to the high intensity of interregional and international interactions. The situation is worst in the Chukotka Autonomous Okrug (46.3 %), the Tver region (59.2 %), the Trans-Baikal region (61.7 %), Mordovia and the Kostroma region. Chukotka and Transbaikalia have a large number of remote settlements, and the rest of the regions have rural settlements. They have a poorly developed backbone digital infrastructure and the proportion of older residents having a low level of education and income is high. Consequently, demand for the Internet is lower. In general, the geographical picture corresponds to the regularities identified in the literature.

The second indicator, the share of households that have access to the Internet from a personal computer (PC) (65.9 % for Russia), is less related to the development of mobile communications and requires households to spend additional money on purchasing a PC. In general, the geographical picture is quite close. In rural and mountainous regions, the cost of services is high due to the difficulties of laying lines, and the unavailability of PCs due to low income. In Ingushetia, Chechnya, and Karachay-Cherkessia, the value of this indicator is below 45 %.

The second type (level) of inequality is the use of digital technologies. During the pandemic, the proportion of Russians with a basic level of digital literacy increased by educating the most lagging behind:[10] from 66 % in 2020 to 70 % in 2021. But not only the ability to use the Internet is important, but also the intensity of its use. The share of active users who accessed the Internet (at home, at work or in any other place) at least once a week is 84.1 %. It is higher in the most financially secure and urbanized regions with many young professionals: Khanty-Mansiysk and the Yamalo-Nenets Autonomous Okrug, Moscow, St. Petersburg, Moscow region. Among the unexpected leaders are the Chukotka Autonomous Okrug, Chechnya, Dagestan, and Kabardino-Balkaria, where the proportion of young residents who are active Internet users is high. They can use the Internet once or twice a week from a working computer, from a mobile device or public access points, etc. In underdeveloped regions, where the share of people employed in the public sector is higher (public administration, education, healthcare), the share of those actively using the Internet may be higher, since these organisations are provided with Internet access through various state programmes.[11]

The share of the population who used the Internet to order goods or services was 40.3 % in 2020, and it is only half the value of the previous indicator (Fig. 2).

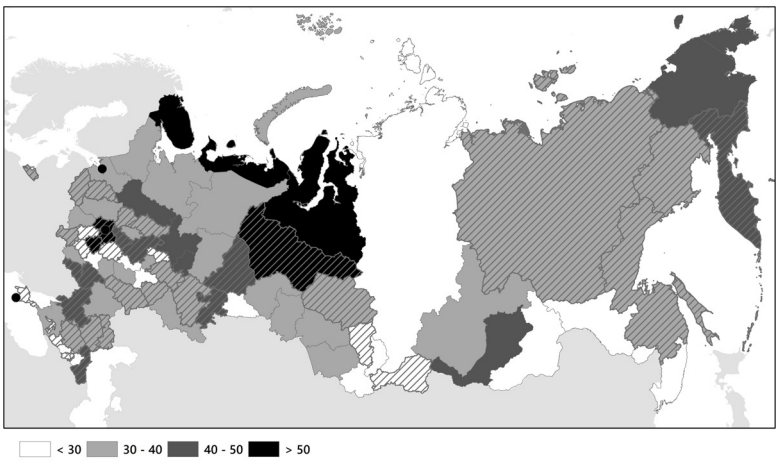

Fig. 2. Share of the population using the Internet to order goods and services in 2020, %

Hatching indicates regions where the value of the indicator increased in 2020, and the growth rate in 2020 was higher than in 2019.

[10] Forced digitalization: a study of digital literacy of Russians in 2021, 2021, *NAFI,* URL: https://nafi.ru/analytics/vynuzhdennaya-tsifrovizatsiya-issledovanie-tsifrovoy-gramotnosti-rossiyan-v-2021-godu/ (accessed 04.07.2021).

[11] For example, within the framework of the national project "Education" all schools in the country should be connected to the Internet.

The leaders are the same rich northern regions and the largest agglomerations in which residents are willing to pay extra for such services. In Moscow and the Moscow region, the value of this indicator is above 60 %, which can be explained by the high level of income, and the wide distribution of such services due to the competition of businesses. In Kabardino-Balkaria, the value is below 22 % due to poor infrastructure development, a high proportion of rural residents in remote mountain settlements, and the spread of shadow businesses that are not interested in using digital technologies, including Internet banking. Online delivery is less developed in most regions of the North Caucasus, in many regions with a large proportion of the elderly population (Ryazan, Oryol, Lipetsk, and Ulyanovsk regions), inland territories having low household income, and in remote settlements located far from large markets (Tyva, Khakassia, and the Krasnoyarsk krai). An unexpectedly low rate is observed in the Primorsky krai, where the price of the Internet is relatively high (Fig. 3).

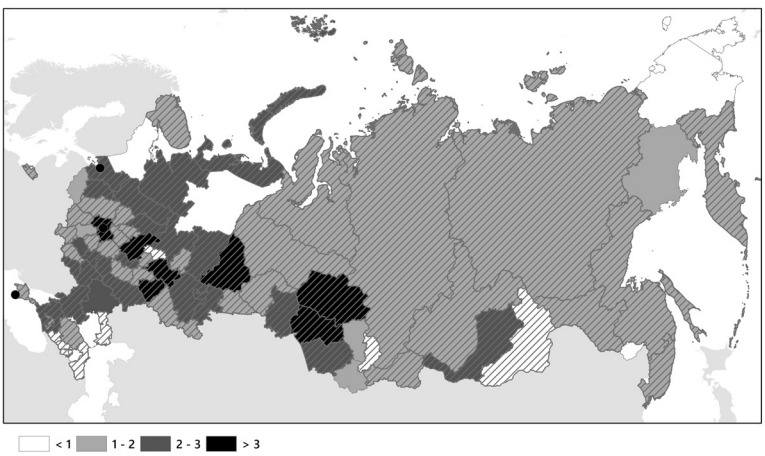

Fig. 3. Share of sales via the Internet in trade, %

Hatching indicates regions where the value of the indicator increased in 2020, and the growth rate in 2020 was higher than in 2019.

The third level of the digital divide is related to the ability of the population and entrepreneurs to get profit from the use of the Internet. In 2020, compared to 2019, there was a significant increase in the share of online sales in Russia — from 2 to 3.9 %. In Moscow, the share of online trade was about 9.3 %, but it is about nil in Chechnya, Chukotka, many regions of the North Caucasus Federal District, and in Buryatia.

The value is higher in large agglomerations (Novosibirsk, St. Petersburg, Tomsk, Nizhny Novgorod, Kazan, Samara) with good household access to the Internet, a high proportion of students, higher demand for internet services, and

developed Internet business. The younger generation is generally more active in using online services. The map (Fig. 3) also shows the influence of businesses in regions with a high level of digitalization on neighbouring ones: the Siberian cluster with the centre in Novosibirsk, the Ural cluster with the centre in Yekaterinburg, Moscow and the Moscow region. Many entrepreneurs start expanding their online stores to neighbouring regions due to the advantages of logistics.

Factors of the digital divide in the Russian regions

To confirm the first hypothesis and the patterns described above, we developed an econometric model that considers three levels of digital inequality (Table 3). At the first level, the availability of the Internet for the population is affected by the cost of connection to the Internet and household income. A 1 % increase in income leads to an increase in the proportion of households having access to the Internet from a home computer by 0.167 %, while an increase in prices reduces it by 0.119 %. It is important to have a large consumer market, where new technologies appear earlier. If in a region the overall income of the whole population is higher by 1 %, then the availability of the Internet is higher by 0.023 %. In other words, the first level of inequality is predominantly determined by economic characteristics.

Table 3

Results of the assessment of factors influencing the level of digital technologies penetration in Russian regions in 2014—2020, %

Variable	Odds estimates
2SLS method	
Equation (1). The third level of the digital divide	
The dependent variable (*intern 5*) is the share of Internet sales in retail trade turnover. The variable is logarithmic	
const	–145.361***
log(*intern3*)	1.739 ***
log(*intern2*)	1.556*
log(*internn*)	0.141**
R^2	0.135
Equation (2). The second level of the digital divide	
The dependent variable (intern 3) is the proportion of the population who used the Internet to order goods and/or services. The variable is logarithmic	
const	3.267***
log(*heurb*)	0.204**
log(*old*)	–0.334***
log(*inform*)	–0.169**
log(*SME*)	0.238***
R^2	0.172

The end of Table 3

Variable	Odds estimates
2SLS method	
Equation (3). The first level of the digital divide	
The dependent variable (intern 1) is the proportion of households that have access to the Internet from a personal computer. The variable is logarithmic	
const	4.019***
$\log(income)_{(t-1)}$	0.167***
$\log(market\_inc)_{(t-1)}$	0.023***
$\log(intprice)$	–0.119***
R^2	0.38

The second level of inequality — the use of the Internet to order goods and services by the population — is associated with the level of education and the average age. If the share of citizens with higher education is 1 % higher, then the share of those ordering online is 0.2 % higher. Less educated and older residents are less likely to use such services due to their inability to do it and their distrust of technology. Institutional conditions are also important [40]. So, if the density of small businesses in the region is 1 % higher, then the share of users increases by 0.24 %. Entrepreneurs compete and invest more actively in the introduction of new technologies and the development of online markets. If informal employment, associated with an unfavourable business environment, is widespread in a region, then the share of users of Internet services is lower. Entrepreneurs tend to hide from supervisory authorities, and are not interested in the digitalization of their services.

The third level of inequality — the ability to profit from using the Internet — is associated with all the previous ones. The spread of online commerce depends on the proportion of the population that has access to the Internet from a personal computer, as it implies the possibility of delivering goods to their homes. The ability to order goods and services directly affects the volume of online trade. In addition, the level of Internet penetration in neighbouring regions is important, which is associated with neighborhood diffusion and the spread of retail chains from large shopping and transport centres that provide online delivery of goods.

Dynamics of the spread of digital technologies and the interregional digital divide during the pandemic

To confirm the second hypothesis about the acceleration of diffusion in 2020, Table 4 summarizes data on the dynamics of indicators in Russia in 2014—2020. According to the theory of diffusion of innovations, the rate of diffusion decreases after reaching 50 % coverage of potential users. In 2018—2019, the decline in growth rates is clearly visible in most indicators. In 2020, growth rates were lower than the average during previous years, except for the expansion of online commerce and broadband Internet. That is, our hypothesis about the acceleration of diffusion is not directly confirmed. But if we consider the stage of expansion, then everything is not so clear, since for most indicators and in most regions (Fig. 1, 2), growth rates in 2020 were higher than in 2019.

Table 4

Dynamics of the spread of digital technologies in Russia, %

Index	Annual growth of the indicator, year on year							Ratio of growth rates		Indicator value	Number of regions with growth rate in 2020 > 2019
	2014	2015	2016	2017	2018	2019	2020	2020/geometric mean for 2014—2019	2020/2019	2020	
The first level of the digital divide											
Share of households with access to the Internet from a home computer	103	102	103	100	98	95	101	99.5	106.3	65.9	56
Percentage of households with broadband Internet access	113	104	106	103	101	101	105	100.4	104.0	85	51
The second level of the digital divide											
Percentage of the population that are active Internet users	106	105	105	104	107	103	103	98.1	100.0	84.1	47
Percentage of the population who used the Internet to order goods and/or services	116	110	118	126	119	103	113	98.2	109.7	40.3	51
The third level of the digital divide											
Share of Internet sales in turnover of retail trade	0	124	138	108	131	118	195	158.1	165.3	3.9	74

A high increase in the provision of broadband Internet access is associated with the transition to distant work, the spread of distance education, and the need for various online services during the pandemic [41]. Higher growth is observed near large agglomerations: the Ryazan, Yaroslavl, Ivanovo, Leningrad, and Samara regions. This may be due to the departure of workforce, including temporary workers, from densely populated large cities. So, for example, in 2020, during the period of self-isolation, 18 % of residents of Moscow left the city (mainly for the Moscow region).[12] The decline in household income in 2020 may have led to the refusal of some households from broadband access services, especially in old-developed and rural regions (in the Smolensk, Saratov, and Tver regions), where the proportion of older and less well-off residents is higher. In terms of the use of a PC to access the Internet in Russia, the maximum values were reached in 2017 (70.3 %), then they slightly decreased due to the competition of other forms of access to the Internet: the use of tablets, smartphones, etc.

In 2020, the share of residents who used the Internet to order goods/services and the share of online trade grew at the highest rates, and the latter almost doubled (from 2 to 3.9 %). In less developed Kalmykia, North Ossetia, Adygea, and Dagestan the share of residents who used the Internet to order goods and services grew the fastest, whereas in the regions that were significantly affected by the crisis [10] — Chukotka, Kabardino-Balkaria, Tambov, Amur regions, and Jewish Autonomous region — it significantly decreased as a result of a drop in income.

Active use of online services accelerated the digitalization of business[13] [40; 42]. Regions with a high proportion of young people — Sakha, Kalmykia, Kamchatka, and the Krasnodar region demonstrated faster online business development rates. The lowest growth rates were observed in the "aged" Pskov region.

The third hypothesis concerning the growth of inequality can be considered refuted, at least at the regional level. In almost all indicators, the digital divide between regions decreased in 2020 (Table 5). Internet penetration levels converged, i.e. the lagging regions grew faster than the leaders, which can be seen from the negative value of the correlation coefficient between the growth of the indicator in 2020 and its value in 2019. We also note that, on average, the differences between regions in access to technologies are lower than in their use. The gap between regions in terms of the share of households having access to the Internet is more than twofold, and in terms of the proportion of the population using the Internet to order goods and services, it is fourfold. The gap in online trade is even larger.

[12] Since the beginning of self-isolation, 18 % of Moscow residents have moved to the Moscow region, 2020, Rossiyskaya Gazeta, URL: https://rg.ru/2020/05/13/reg-cfo/s-nachala-samoizoliacii-18-zhitelej-moskvy-pereehali-v-podmoskove.html (accessed 14.11.2021).

[13] In 2020, many enterprises were forced to switch to digital technologies during the pandemic [43] to survive. There was digitalization of everyday processes, mainly documentation flow (39 %), and communications (24 %). More complex management technologies, for instance Agile, Lean (15 %), were used less frequently. A quarter of companies were not engaged in digitalization.

Table 5

Indicators of the level of the interregional digital inequality and convergence of regions, %

Index	The coefficient of variation		The ratio of the maximum value to the minimum		Theil index		Correlation coefficient between the growth of the indicator in 2020 and its value in 2019
	Average, 2014—2019	Value, 2020	Average, 2014—2019	Value, 2020	Average 2014—2019	Meaning 2020	
The first level of the digital divide							
Percentage of households accessing the Internet from a personal computer	0.15	0.15	3.9	2.1	0.012	0.011	–0.4
Percentage of households with broadband Internet access	0.14	0.1	2.7	2	0.012	0.005	–0.5
The second level of the digital divide							
Percentage of the population that are active Internet users	0.09	0.06	1.7	1.3	0.004	0.002	–0.54
Percentage of the population who used the Internet to order goods and/or services	0.39	0.28	7.96	4.6	0.076	0.037	–0.55
The third level of the digital divide							
Share of online sales in retail turnover	1.45	0.78	N/A	N/A	N/A	0.246	–0.27

Conclusion and recommendations

In accordance with the first hypothesis, it was possible to confirm the regularities identified earlier in the literature. The spatial structure of the spread of digital technologies between the Russian regions depends on the income, average age and level of education, whereas their use depends on the current business climate. Geographic factors are also important, particularly, proximity to sources of innovation (neighborhood diffusion) and the size of the central city (hierarchical diffusion). The work revealed that in some northwestern regions of Russia (the Kaliningrad region, Karelia, and St. Petersburg) the level of penetration of digital technologies is higher than the regional average due to the proximity of the European centres of innovation.[14]

As a result of the pandemic, the spread of digital technologies accelerated in 2020, but only in comparison with what was potentially expected. It only partially confirms the second hypothesis. Growth rates should have been declining according to the downward trend of the late stages of diffusion [15; 18].

The digital divide between Russian regions narrowed in 2020 due to the accelerated spread of new technologies in lagging regions (convergence), which refutes the third hypothesis.

Based on the study, it is possible to formulate some recommendations for regional authorities. To reduce the digital divide, it will be necessary to support the creation of ICT infrastructure in the least depopulated territories of the lagging regions (the Tver, Zabaikalsky, Kostroma regions, and some others), as well as in the North Caucasus regions. The development of programmes aimed at providing laptops and PCs to the most socially vulnerable households, as well as subsidizing Internet traffic, will be particularly beneficial. The constant work of qualification and employment centres is important for increasing the digital literacy of the population, including that of the elderly population. It is advisable to increase the level of trust in digital technologies. As part of the Digital Economy National Project, a further increase in recruitment for the digital sector is a possible solution.

To support the dissemination of the latest technologies in the leading regions and the largest agglomerations, it is necessary to subsidize the introduction of priority multi-purpose digital technologies (Internet of Things, telemedicine, online education, etc.) in the public sector with a further distribution throughout the country. It is required to improve the availability of digital technologies with the help of subsidized business digitalization programmes using standard technological solutions [44]. This will partially help to overcome the problems of the low penetration of the Internet economy in Russia.

[14] A classic example is the emergence of the Internet at Petrozavodsk State University (Karelia) earlier than in many Moscow universities, thanks to the cooperation with Finnish telecommunications companies (for example, Nokia) and universities. Finland is one of the leaders in the speed of digitalization of the economy in the world.

In general, the growth of digitalization and employment in the ICT sector can be considered as one of the ways to adapt to the consequences of global changes [7; 18; 44].

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