The impact of digitalization on the Russian economy

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THE ECONOMIC IMPACT OF DIGITALIZATION IN RUSSIA

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Abstract
Subject. The development of digital technologies and their impact labor productivity and economic growth in the country.
Objectives. Measuring the impact of digital technologies on labor productivity and economic growth in Russia.
Methodology and Data. The regression estimation was carried out by the Two-Stage Least Square method. Information and communication technology (ICT) expenditures and investment in assets aimed at purchasing ICT equipment were used as input variables. In line with previous authors' research, the regression equation is supplemented with measures of change in the ICT sector: ICT infrastructure extent, ICT usage, and ICT consumer empowerment. The data of Rosstat, the Bank of Russia and the International Data Corporation were used.
Results. Our results indicate the presence of common properties of ICT development on labor productivity and economic growth. The statistically significant impact of ICT Spending and Investment of ICT was found on labor productivity and economic growth. The influence of ICT infrastructure development indicators on the studied variables is insignificant. ICT usage and empowerment are not statistically significant.
Conclusion. The positive impact of the growth of ICT Spending and ICT Investments on Labor productivity and Economic growth in Russia has been established. However, the hypothesis about the positive impact of ICT infrastructure development on these indicators is not confirmed.

Keywords: digital technologies, information and communication technologies, labor productivity, economic growth.

JEL: E22, E24, O33

1 Introduction

The digital economy is turning from the era of the future into reality. However, this process is developing unevenly. There is activity in certain segments of the economic and social life of people and companies, but the economic effects differ across countries and regions. Among the main reasons for the high demand for digital technologies (DT) and Blockchain are called "the increasing demand for simplification of business processes, low transaction costs, transparency, continuity, speed, peer-to-peer interaction of economic entities, almost unlimited number of use scenarios in any industry" [1].

A quantitative assessment of the processes related to the development of the digital industry is not yet possible for several reasons. Firstly, there are no uniform standards and recognized scientific methods for assessing the level of development and the economic effect of the introduction of digital technologies. Secondly, DT introduction processes are implemented primarily at the enterprise level. And due to the uneven development of digital technologies in the context of regions and countries, there are no verifiable statistical data on the level of technology development, and their direct impact on social and economic development existent at the macro level. The main indicator for assessing the level of development of the digital economy among researchers is the Information and Communication Technologies (ICT) spending or the share of products manufactured using DT in the total volume of the country's economy [2-5]. Most econometric estimates of the impact of ICTs focus on the impact of these technologies on economic growth and productivity [6-10]. The results are mixed, with positive, neutral and even negative impacts of ICT implementation on productivity and economic growth reported. Estimation of the impact of digitalization on the social phenomena and integration processes of all segments of society is difficult due to the lack of high-quality and homogeneous information.

Some authors propose to assess the level of development of the digital economy through comparative or competitiveness analysis. For example, in the (Mukhomorova I.V. et al.) for assessing the competitiveness of the digital economy are identified next five directions: “(1) competitiveness of economy as the territory for doing digital business, (2) competitiveness of digital products that are manufactured in this economy in the world markets, (3) competitiveness of economy as a territory of residence of digital human, (4) competitiveness as the level of innovativeness of the digital economy and (5) competitiveness as effectiveness of the digital economy”[11].

In a qualitative aspect, the problems of modernization of management (QM) associated with digitalization processes are investigated [12]. Special attention should be paid to studies aimed at finding answers to social challenges, including employment [6, 12], problems of inequality [13], education [14] and various models of implementation and use of ICT [15-17].

There are examples of a comprehensive assessment of the level of digital competitiveness. Institute for Management Development (IMD) methodology of the World Digital Competitiveness (WDC) ranking defines the digital competitiveness into three main factors (knowledge, technology and future readiness), comprised from 51 criteria [18]. Have are differences in digital adoption and digital competitiveness between developed and developing countries. If for the first countries the basis of the digital competitiveness of the economy is a high level of integration of ICT and devices, and an barrier is the low interest of business in digital modernization, for the second countries the situation is the opposite, which is associated with a low level of integration of ICT and devices and a great interest of business towards digital modernization [5]. Concluding the introduction, we note that today there is no unified approach to the terminology of digital technology products. Often we are not yet able to identify as separate definitions "Digital Technologies" and "Information and Communication Technologies" [19].

In this study, we will proceed from the principle that the implementation of ICT is a prerequisite for the development of the digital economy and has a real impact on economic growth. Based on the foregoing, the purpose of the study is to measure the impact of digital technologies on labor productivity and economic growth in Russia.

The main hypothesis of this study is that the growth of ICT Spending, Investment of ICT and ICT empowerment are positive prerequisites for the impact of digitalization on economic growth and labor productivity.

2 Methodology

Based on the materials of the mentioned studies, we have identified the most methodologically relevant works [6, 13, 14, 15, 16, 17], where the impact assessment of digital implementation is implemented at the level of economic growth and social externalities. Next, we compared data on ICT implementation using selected authors and settled on the methodology presented in the work of Evangelista R. et al. [6]. Following this work, the directions of the econometric assessment of digital implementation (ICT implementation) were selected for the following indicators:

a) Labor productivity;

b) Growth of GDP per capita;

To optimize the econometric estimate for Russian statistical data, the HC variable, which reflects the change in the quality of human capital, is replaced by the ICT variable, which reflects the change in the ICT-spending. And the variable INV in our model reflects the change in fixed capital investments aimed at acquiring ICT.

Thus, to estimate the efficiency of digitalization on the labor productivity is used the formula:

$$LPROD_{it} = \alpha_0 + \alpha_1 ICT + \alpha_2 INV + \alpha_3 INFRA + \alpha_4 USAGE + \alpha_5 EMPO + é_{it} \quad (1)$$

where LPROD is the rate of growth of labor productivity (measured as the ratio of GDP in constant prices to the number of employees);

ICT - changes in ICT costs,

INV - change in investments in fixed assets aimed at the acquisition of ICT equipment,

INFRA, USAGE and EMPO - annual changes in digitalization indicators (respectively "infrastructure", "usage" and "empowerment").

To estimate the efficiency of digitalization on the economic growth is used the formula:

$$GDPPC_{it} = \alpha_0 + \alpha_1 ICT + \alpha_2 INV + \alpha_3 INFRA + \alpha_4 USAGE + \alpha_5 EMPO + é_{it} \quad (2)$$

where GDPPC is the growth rate of GDP per capita (measured as the ratio of GDP in constant prices to the total population).

The method of calculating the ICT development indicators (INFRA, USAGE and EMPO) used in the models is adopted from the [13, pp. 241-245].

Both equations were estimated by the Two Stage Least Squares (TSLS) method. Heteroscedasticity test consisted using White's method.

3 Data selection and analysis

Following [13], we have compiled three groups of ICT development indicators (Table 1).

Table 1. Infrastructure, Usage and Empowerment indexes of digitalization: sub-dimensions, indicators and data sources

ICT-Infrastructure
Network
1. Broadband penetration rate (mobile+household) (Rosstat)
2. International Internet bandwidth per inhabitant (bit/s) (WDI)
3. Secure Internet servers (1 million people) (WDI)
Affordability
1. Information and communication technology expenditure per capita (WDI)
Availability and quality
1. Internet subscribers fixed broadband per 100 inhabitants (Rosstat)
2. Internet subscribers fixed per 100 inhabitants (Rosstat)
3. Level of Internet access for households (Rosstat)
4. Percentage of households using a broadband connection (Rosstat)
ICT-Usage
Autonomy
1. Percentage of individuals who accessed Internet at home (Rosstat)
Intensity
1. Percentage of individuals who accessed Internet every day or almost every day (Rosstat)
ICT-Empowerment
Economy
1. Percentage of individuals who used Internet for Internet banking (BoR)
2. Percentage of individuals who ordered goods or services for private use over the Internet (Rosstat)
Labor
1. Percentage of persons employed using computers connected to the Internet in their normal routine (Rosstat)

The presented data that participate in the European Digital Development Index (EDDI) and are freely available on the website of the Federal State Statistic Service of the Russian Federation (Rosstat), the Central Bank of the Russian Federation (BoR) and World Development Indicators (WDI). The missing data were obtained from the Statistical Digest "Indicators of the Digital Economy" of the Higher School of Economics (https://www.hse.ru/primarydata/iio).

Many studies have been devoted to the problem of choosing the correct indicators for assessing the development of ICT [13, 18,

20, 21], where the authors propose to evaluate the level according to a wide range of criteria (from 7 to 28). This study is limited to the indicators that we have at our disposal. A complete set of indicators in accordance with [11] is available only for the sub-dimensions "ICT-Infrastructure". There are no indicators of the “Skills” group for the sub-dimensions "ICT-Usage". And the sub-dimensions “ICT-empowerment” are recommended to be assessed by 14 indicators combined into six groups. We have (Rosstat data) only two indicators combined into the “Economy” group and one indicator that represents the “Labor” group.

Calculation data indicate a significantly higher level of ICT development in the period after 2016. In particular, from 2010 to 2019, the growth according to the indicator “International Internet bandwidth per inhabitant” was 3.6 times, and according to the indicator “Secure Internet servers per 1 million people” – 546 times.

When normalizing data, the authors of [13] use different methods, which makes could be replicate the methodology in assessing the DT development in different countries. We took advantage of this opportunity.To estimate models (1) and (2), we adjusted the ideal levels of some indicators. Instead of 5, we use 10 as the ideal level for the “International Internet bandwidth per inhabitant” indicator, and when evaluating the “Secure Internet servers per 1 million people” indicator, the ideal level grows by 1 unit every year: from 6 in 2010 to 15 in 2019.

The dynamics of development for all three sub-dimensions is presented in Figures 1-3. The graphs are shown using ideal levels corresponding to paper [13].

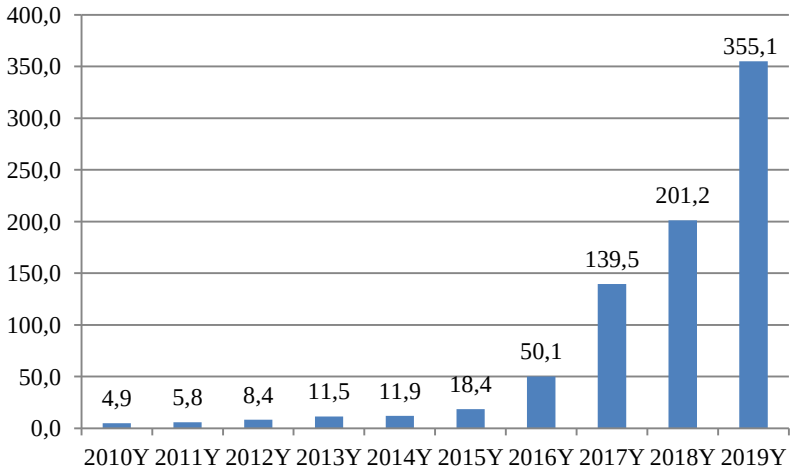

Fig. 1. ICT-Infrastructure index development of Russia, *Source: Authoring*

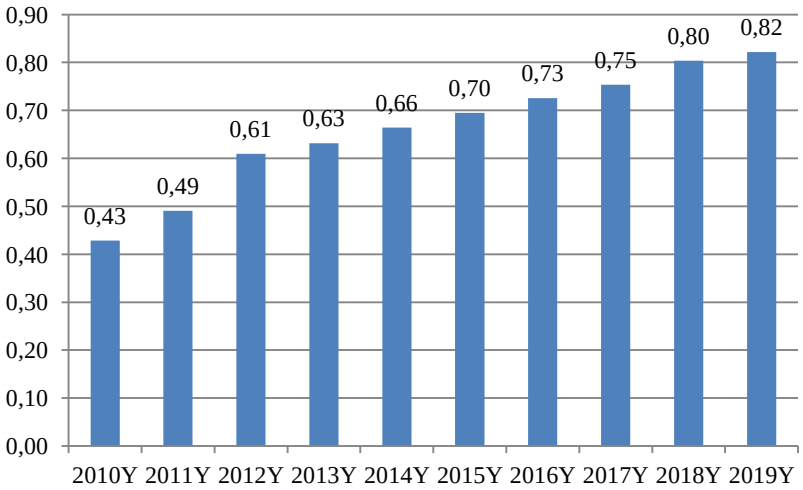

Fig. 2. ICT-Usage development of Russia, *Source: Authoring*

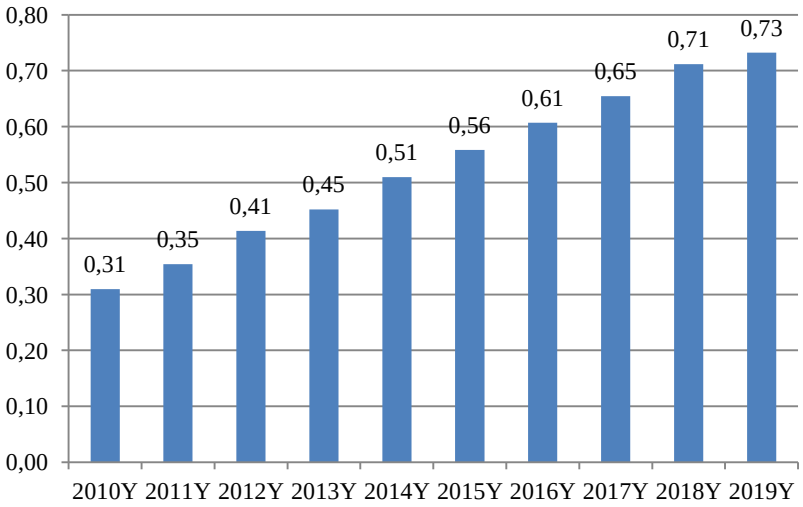

Fig. 3. ICT-Empowerment development of Russia, *Source: Authoring*

4 Results of estimation

The results of evaluating equations (1) and (2) are presented in tables 2 and 3, respectively. All models are examined in the GRETL econometric module. In both models, adequate coefficients (P-value < 0.05) were obtained in the case of estimating the equation with a lag of one year for the variables ICT and INV. This fits into the hypothesis that the effect of the introduction of new ICTs should manifest itself with a time delay. Both models successfully passed the Hausman test for the absence of endogeneity and the consistency of the least squares estimates. The second round of estimation was performed with Robust standard errors. In the second cycle as an independent variables used of ICT Spending and Investment in ICT; as tools: ICT Spending, ICT Investment, Infrastructure, Usage, Empowerment and Const.

Contrary to expectations, and in line with most of the literature on the study of economic growth and labor productivity from the development of ICT, the results suggest the need for cautious estimates. Our results indicate that there are common characteristics of ICT development on labor productivity and

economic growth. In particular, in both models, ICT spending and ICT investment have a statistically significant effect on the independent variables. This is in line with our expectations. Indicators of ICT infrastructure development, changes in ICT use on people and enterprise, and empowerment show mixed results. Both models demonstrate statistically significant results only for the "Infrastructure" indicator. In this case, the coefficients are too small. The impact of improving ICT-Infrastructure on labor productivity is 0.0017, and 0.0054 on economic growth.

Table 2. Impact of ICT development indicators on labor productivity in Russia

Variables	*Coef.*	*Z-value*	*Prob.*
Constant	0.7421 ***	14.6379	0.0000
ICT Spending	0.1063 ***	4.7479	0.0000
Investment of ICT	0.0938 ***	2.7983	0.0051
Infrastructure (change)	0.0017 ***	3.7957	0.0002
Usage (change)	-0.0556	-0.2012	0.8406
Empowerment (change)	0.5837	1.3579	0.1745

In the TSLS model. Independent variables: ICT Spending, Investment of ICT;
Tools: ICT Spending, Investment of ICT, Infra, Usage, Empowerment, const;
Z-values are based on heteroscedasticity consistent standard errors (using White's method);
*, **, *** denote respectively statistical significance at 10, 5 and 1%.

Table 3. Impact of ICT development indicators on economic growth in Russia

Variables	*Coef.*	*Z-value*	*Prob.*
Constant	-0.0731 ***	-0.1550	0.8768
ICT Spending	0.4780 ***	2.7172	0.0066
Investment of ICT	0.3176 *	1.7274	0.0841
Infrastructure (change)	0.0054 *	1.8894	0.0588
Usage (change)	-1.2954	-1.0029	0.3159
Empowerment (change)	4.1149	1.5492	0.1213

In the TSLS model. Independent variables: ICT Spending, Investment of

ICT;
Tools: ICT Spending, Investment of ICT, Infra, Usage, Empowerment, const ;
Z-values are based on heteroscedasticity consistent standard errors (using White's method);
*, **, *** denote respectively statistical significance at 10, 5 and 1%.

The results for variable Usage and Empowerment in both models are statistically insignificant. These lead to contradictory conclusions. Thus, the changes in the level of use of ICT has a negative impact on the labor productivity and economic growth. And changing empowerment has a strong positive impact, which is alarming.

It is used that the negative impact on the level of use of ICT infrastructure can explain the high level of penetration of digital technologies, and their powerful increase, when labor productivity and economic growth simply do not keep pace with these changes. The reason for the excessively high level of coefficients for the Empowerment variable may be the multicollinearity of the data, which the TSLS method we use cannot fully overcome.

Thus, examining the impact of ICT technologies and digitalization of society on labor productivity partially confirmed our hypothesis. Increased spending on ICTs, their infrastructure, and fixed capital investments aimed at purchasing ICT equipment lead to a moderate growth in labor productivity. A more significant effect of these indicators is observed on economic growth.

5 Conclusion

Based on the traditional approach to the effectiveness of digital investments and ICT spending, we tested two models of the impact of ICT development, the level of their use and the effect of empowerment on labor productivity and economic growth. The study of the impact of ICT technologies and digitalization of

society on labor productivity partially confirmed our hypothesis. The growth in ICT spending, their infrastructure and investment in fixed assets aimed at the acquisition of informational, computer and telecommunications equipment lead to a moderate increase in labor productivity. The same indicators have a more significant effect on economic growth. A small but positive relationship to the labor productivity and economic growth was found in the indicator of changes in the availability of ICT-infrastructure. The impact of indicators of the level of use by the population and enterprises of ICT and the effect of empowerment has not been reliably established. In our opinion, the reasons for the ambiguous results of the assessment are the limitations of: (1) the indicators used for the development of ICT and digitalization, and (2) the small depth of statistics on the development of ICT and the digital economy.

Our examination shows that investment in ICT infrastructure and the subsequent development of ICT infrastructure are effective factors in the growth of labor productivity and the economy. However, the impact of changes on the digitalization of life leaves a number of questions unanswered. We intuitively understand that not so much the availability of ICT tools as their use and empowerment effect is more significant conditions for the transition to a digital society. Consequently, further studies of this scientific problem should go in the expanding the indicators involved in the formation of indexes of ICT development and digitalization. In map of collecting and systematizing information on the level of development of wide range indicators of DT in the country, the work of the Federal State Statistics Service of the Russian Federation (Rosstat) should be expanded. Approaches to the normalization of European digitalization development indicators (EDDI) also remain an urgent problem due to the extremely fast increase in the indicators included in them.

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I, the author of this article, bindingly and explicitly declare of the partial and total lack of actual or potential conflict of interest with any other third party whatsoever, which may arise as a

result of the publication of this article. This statement relates to the study, data collection and interpretation, writing and preparation of the article, and the decision to submit the manuscript for publication.