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Abstract: The paper is devoted to the study of the spillover effects of digitalisation. The assessment of the spillover effects of digitalisation forms a methodological basis for the implementation of the state policy of digital development. The authors systematised the positive and negative spillover effects of digitalisation for the economy. The expediency of using statistical methods of variance and standard deviation to evaluate the spillover effects is substantiated. It is proved that the spillover effects of digitalisation are subject to management by the state. This will ensure that developing economies accelerate digital development and expand their opportunities to achieve global leadership.

Keywords: spillover effects of digitalisation; digital economy; labour market; deformation; unemployment; digital inequality; cyber risks; asymmetry; management; state policy.

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1 Introduction

Digitalisation processes change the essence of production processes – digital technologies and information resources become the basic factors of production, and the process of creating goods and services becomes remote and integral (OECD, 2017). The mechanisms and nature of relations between economic entities are changing, they acquire features of network and virtual interaction, most often reaching the global level (Pilipchuk et al., 2024).

The habitual human environment, as well as the consumption model, is being transformed. Multifunctionality, personification and intelligence become the determining characteristics of a product or service that define its position in the market (Molchan et al., 2019).

Such fundamental changes, on the one hand, require appropriate investments related to the introduction of digital technologies and the restructuring of the main socio-economic processes, and, on the other hand, provide the benefits of digitalisation in the form of additional profits, increased productivity and accelerated economic growth.

Many authors investigate the effectiveness of the digital economy and note that the real economic consequences of digitalisation are much broader and more multifaceted (Volodina et al., 2011; Karpunina et al., 2019a, 2019b, 2019c, 2021; Nikiforova et al., 2020; Fraymovich et al., 2022). Thus, companies implementing digital technologies receive both private benefits from investments and related benefits, for example, in the form of improving the reliability of services, increasing the company’s competitive advantages, obtaining a wider set of technologies and opportunities for their flexible application (Kuzovkov et al., 2019; Cherepovitsyn and Solovyova, 2022).

The existence of digital side effects is stated in the report of Huawei and Oxford Economics (2017) “Digital Spillover”. The calculations presented in the report confirm that digital transformation affects not only an individual company, it covers the supply chain, related industries, which ultimately leads to a significant positive impact on the economy as a whole (United Nations, 2019b).

The side effects of the introduction of digital technologies often exceed the direct ones, however, at present they are little identified and practically not evaluated. In addition, the spillover effects of the digital economy are not always positive.

Thus, to increase the effectiveness of the state policy of digital development, it is necessary to manage the spillover effects of digitalisation. This requires their identification and subsequent evaluation, as well as a mechanism for implementation into the public administration system.

2 Literature review

A significant number of scientific papers have been devoted to the study of the digital development patterns. Thus, the attempt to determine a logic for the digital economy formation through the allocation of digitalisation waves belongs to Katz (2017). Atkinson et al. (2009), Varian et al. (2002), Gillett et al. (2006) focused on identifying the economic and social benefits that the economic system and society receive from the introduction of digital technologies. For example, increased productivity as a result of implementing more efficient business processes supported by information and communication technologies (ICT), as well as optimising the supply chain, reducing overall costs.

Brynjolfsson and McAfee (2014), Katz (2017), and Gordon (2012) describe both the positive and negative consequences of digitalisation (for example, the reduction of the medium-and low-skilled workforce as a result of particularly strong capital replacement, as well as a slowdown in labour productivity). However, the authors do not separate the main and side results of digitalisation.

Meanwhile, the concept of ‘spillover effect’ (that is, the manifestation of any economic activity that affects the activities of third parties that are not directly involved in the interaction process) is most often found in the innovation management theory (Pittaway et al., 2003), when assessing the intra-industry impact of foreign companies’ investments and identifying positive effects (Buckley et al., 2007; Wang and Zhao, 2008), analysing the R&D sphere (Coe et al., 2009; Kim and Lee, 2004), as well as in the process of assessing the spread of knowledge (Kesidou and Szirmai, 2007; Wang et al., 2009).

In the process of innovation management, there are horizontal spillover effects (innovations are copied by other companies, which leads to raising productivity), vertical (increasing productivity when delivering goods and services along the supply chain) and internal (through training in practice) (Teece, 1977).

Researchers point to the emergence of spillover effects from foreign direct investment both within the industry and along the technological chain, as well as the likelihood of not only positive, but also negative side effects (Fedorova and Barikhina, 2015). The methodology for studying spillover effects in the process of knowledge dissemination is based on two approaches:

- 1 MAR Spillovers (Knowledge spillover) explains how the concentration of firms in one industry helps move knowledge between firms (Edward et al., 1992)
- 2 Jacobs Spillovers shows how the concentration of different industries in one place encourages innovation (Carlino, 2001).

The source of side effects of the digital economy can be the economic effect of the scale of production and consumption of services; individual consequences of the formation of added value for goods and services; social effects of scientific and technological progress for human life (Kuzovkov et al., 2019).

3 Research methodology

The purpose of the study is to identify, systematise and develop a methodology for assessing the spillover effects of digitalisation as a basis for the formation and implementation of the state policy of digital development.

Research objectives:

- analysis of the direct effects of digitalisation on the economy and society
- systematisation of the spillover effects of digitalisation for the economic system
- development of methodological foundations for assessing the spillover effects of digitalisation
- formation of conclusions on the management of the spillover effects of digitalisation for the state policy of digital development.

The authors suggest using the statistical method of variance and the mean square deviation to evaluate spillover effects.

The authors propose to use the following formula to estimate the spillover effects by using dispersion:

$$\sigma^2 = \frac{\sum (x - \bar{x})^2}{n} \quad (1)$$

The average square deviation formula has the following form:

$$\sqrt{\sigma^2} = \sqrt{\frac{\sum (x - \bar{x})^2}{n}} \quad (2)$$

The initial indicators for evaluating the spillover effects of the digital economy can be: Unemployment rate (TakeProfit, 2020); human development index (HDI), adjusted for inequality in access to technology (United Nations, 2019a); Cybersecurity Index (ITU, 2019).

4 Results and discussion

4.1 Direct effects of the digital economy

Considering the digital economy in terms of a resource approach allows to identify the resources and factors that make up its basis:

- 1 generated human knowledge and skills
- 2 digital infrastructure resources in the form of internet access and information use opportunities
- 3 research and development as the basis of technological innovation
- 4 digital technologies based on artificial intelligence, robotics, AR/VR and blockchain.

Creating and managing these resources requires significant investment from individuals, businesses, and the state.

The education sphere is the base for the digital economy formation. Access to education for all categories of the population, as well as the level of professional competence, is largely determined by the standard of living of the population in a particular country, their income level, as well as support from the state. Experts use the Global Index of Cognitive Skills and Educational Attitude to assess the effectiveness of national education systems (Pearson, 2016). It is based on a ranking on two groups of international indicators: cognitive skills and educational level (including the literacy index and the index of the total percentage of students receiving secondary and higher education). In 2016, US ranked first in the world (100 points), Switzerland was second (87.2), Denmark ranked third (84.2), and UK was fourth (84.8). Germany (70.3) was on 16 positions, Japan (64.2) – on 20, China (51.8) – on 30, Russia (49.1) – on 34, South Africa (45.6) – on 37, Brazil (45.1) – on 38, India (45.8) – on 49. In turn, the effectiveness of the education system determines the opportunities for human development. Thus, in 2018 Germany (0.939), UK (0.920), US (0.920), and Japan (0.915) were included in the group of countries with a very high level of HDI; Russia (0.824), Brazil (0.761), China (0.758) are middle-level HDI countries, while South Africa (0.705) and India (0.647) are classified as low-level HDI countries (United Nations, 2019a).

The formation of a digital infrastructure is a prerequisite for the digital economy development (Nikiforova et al., 2020). The gap in internet access between countries and regions of the world remains significant. For example, the values of the indicator “ICT access and usage by households” in 2019 are as follows: in the US-79.88% of households have internet access from home (79.1% – broadband access), in the UK-96.85% (95.84%), in Germany-94.83% (93.93%) China – 59.6% (54.3%), in Russia –76.3 % (21.4%), in Brazil –71.4% (63%) (OECD, 2020). The level of access to the internet and the use of digital technologies by business structures also differs significantly. For example, in the UK, 94.68% of business structures have fixed and mobile internet connections, 23.87% of all business structures use ERP technologies, 30.51% use CRM services, and 17.85% of enterprises have connection speeds above 100 MB/s, while in India and a number of developing countries, the value of similar indicators remains low (OECD, 2020).

The structure of R&D financing varies from country to country. For example, in US, Japan, European countries and China, a large share of all investments in the ICT sector is taken by businesses, while in developing countries such as Russia and India, government support is high (Table 1).

For example, in the UK in 2016, the total amount of investment in R&D was 1.67% of GDP, including the amount of public investment was 0.67% of GDP, private investment – 0.86% of GDP, 0.34% of GDP accounted for other investments by private non-profit organisations from abroad, including business financing programs outside the UK and the EU. Thus, the British innovation Agency is the main source of funding for British public innovation (more than 8000 organisations received support), in addition, other organisations (regional agencies, the Fund for energy entrepreneurs of industrial strategy, the Royal Academy of engineering, etc.) have provided positive experience of public funding. The UK government plans to increase investment in this area to 2.4% by 2027, and in the long term – to 3% of GDP (Royal Academy of Engineering, 2018).

At the same time, increased government funding will also require growing business investment and more R&D projects to achieve success (Ponomarenko et al., 2022).

Table 1 Expenses of some countries for the R&D sphere development

Country	GDP (current prices)/ billion US\$), 2019	Gross domestic spending on R&D, % of GDP	R&D spending by government, % of total R&D	R&D spending by Business, % of total R&D spending in PPP\$	R&D spending by Universities and Private non-profit, % of total R&D	Number of researchers per million inhabitants	Direct government funding of business R&D and tax incentives for R&D, 2015
USA	21,427	2.7	11.4	71.5	17.1	4205	0.13
China	14,342	2.0	15.8	77.3	6.9	1089	0.06
Japan	5081	3.4	8.3	77.8	13.9	5328	0.02
Germany	3845	2.9	14.6	67.65	17.7	4320	0.07
UK	2827	1.7	7.26	65.1	27.64	4227	0.09
Russia	1699	1.1	30.48	59.6	9.92	3075	0.38
India	2875	0.7	56.5	37.1	6.4	156	0.008
Brazil	1839	1.3	x	x	x	887	0.09
South Africa	351	0.8	23.5	45.3	31.2	432	0.01

Source: Compiled by the authors according to OECD (2020), UNESCO Institute for Statistic (2020) and World Bank (2020)

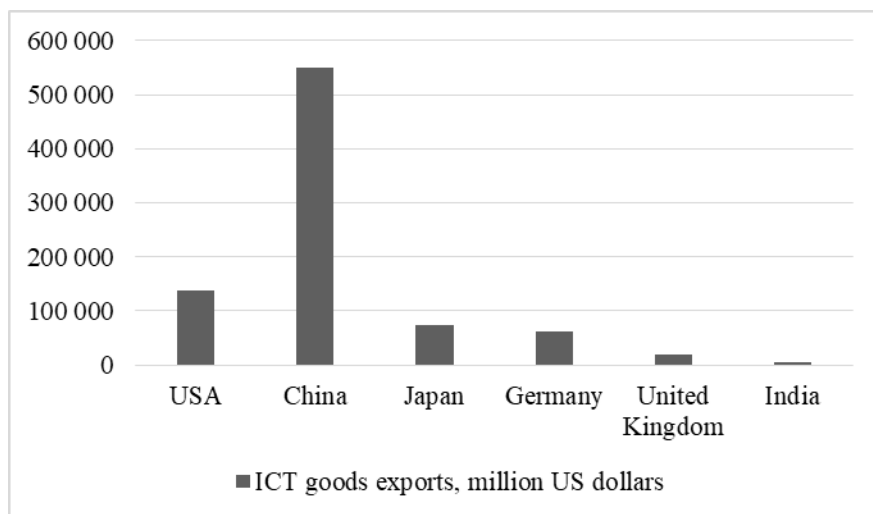
According to IDC (2020), in 2018, 4.7 million US dollars were invested in IT technologies, of which 4.0 trillion US dollars were invested in traditional technologies, 0.7 trillion US dollars in new technologies. In 2019, there was a further increase in ICT spending (+5.5%). However, a new trend has emerged to reduce traditional spending on hardware, software, services and telecommunications. This is because the savings from automation can be invested in new technologies (for example, artificial intelligence, robotics, AR/VR and blockchain) that provide a faster return on investment for targeted industrial applications. Positive experience is demonstrated by Asian countries, where manufacturing enterprises are actively implementing artificial intelligence technologies and robotic solutions.

In developing countries, Governments are encouraging investments in new technologies, and examples of the creation of ‘smart cities’ confirm the effectiveness of the integration of ICT and economic planning. Currently, almost all countries have adopted a national digital development strategy. Issues of improving digital infrastructure, training specialists for the digital industry, creating a strong basis for scientific research, stimulating innovative activity of enterprises, and ensuring cybersecurity come to the fore. And there are many such examples now: ‘Industry 4.0’ (Germany); New Information and Communication Technology Strategy (Japan), Digital Economy Law (UK); Digital Economy Agenda (USA); Internet+ (China). When deciding on the implementation of a digital development strategy (in some of the listed countries, the second and third programs have been adopted), governments aim not only to intensively develop the ICT sector, but, above all, to improve the quality of life of the population (Karpunina et al., 2019a)

Investments in digital technologies demonstrate the effect of the growth of the ICT sector and related fields of activity. Since 2000, as digitalisation processes have increased, the volume of the ICT sector has doubled, and its growth rate is two and a half times higher than the growth rate of global GDP. In 2016, the global digital economy was estimated at \$11.5 trillion, or 15.5% of global GDP, while in developed countries it averaged 18.4% of GDP, in developing countries – 10% of GDP (Huawei and Oxford Economics, 2017).

The maximum volume of exports of ICT goods, as a reflection of the costs of digitalisation, in 2019 was reached by China – 138,651 million US dollars, the second place in the world remains with the US-138,651 million US dollars (Figure 1).

Figure 1 The structure of ICT goods exports, million US dollars



Source: OECD (2020)

The direct effects of digitalisation are estimated as productivity increases.

Jorgensen et al. (2005) assessed the impact of ICT on multi-factor productivity in US and concluded that there is a delayed social and economic impact of various digitisation waves.

The digital economy removes scalability constraints (digital technologies create an increased need for factor resources and meet additional final demand) and allows traditional sectors to grow at a faster pace. Growth is reflected in increased revenue from expanding market coverage (Varian et al., 2002, Gillett et al., 2006; Nikiforova and Nikiforov, 2021).

Katz (2017) notes that using broadband internet access increases the efficiency of business processes and services and reduces overall costs.

An increase in the index of the digital economy ecosystem development by 1%, (due to the development of e-Commerce, e-government, e-health), led to an increase in GDP per capita in Latin America by 0.13%, noted Katz and Callorda (2017).

According to Barefoot et al. (2018), it was the digital economy that became the engine of GDP growth in US. During the ten-year period 2006–2016, the real value added of the digital economy outstripped the overall economic growth and, in many

ways, offset the negative effects of the decline in GDP during the recession in 2008–2009.

4.2 Identification and assessment of spillover effects of the digital economy

Potential spillover effects from digital investments also affect certain areas of social and economic life and the national economy.

The classification of spillover effects can be based on various features. Traditionally, the “nature of interaction of subjects” is used as a criterion for classifying spillover effects in innovation and investment activities (Dudina et al., 2021). According to this criterion, there are vertical spillover effects that occur between companies that are in a relationship, and horizontal spillover effects between other companies operating in the same market. They also identify technological spillover effects that occur when technologies are diffused, such as assimilation of foreign technologies or productivity gains resulting from the use of more advanced technologies (Chengqi and Zhongxiu, 2008; Samylovskaya et al., 2022).

Researchers emphasise that spillover effects can be manifested in the form of providing the market with new products of high quality, diversifying product lines, increasing the efficiency of companies in terms of costs and profit margins (Filatova et al., 2021).

In our opinion, we can distinguish the following spillover effects of the digital economy.

1 Spillover-the effect of changes in the labour market and employment

Thus, in the first wave of digitalisation, a positive spillover effect was obtained in the form of employment growth (Katz, 2017). For example, Crandall et al. (2007), Shideler et al. (2007) empirically proved that a reduction in resource constraints during this period led to an increase in demand for labour and job creation, usually in service industries (such as financial services, education, health, etc.), as well as in manufacturing. Katz and Callorda (2016) also confirmed that between 2004 and 2015, a 1% increase in the digitisation of the consumption index resulted in a 0.07% decrease in the unemployment rate.

However, Akerman et al. (2015) indicates that digital technologies and automation contribute to the polarisation of jobs in most developed countries due to the limited digital skills of the population. Low- and medium-skilled jobs are prone to disappearing due to the introduction of advanced technologies.

Fossen and Sorgner (2019), based on mapping the impact of digitalisation on professions, calculated the median values of indicators weighted by the number of people employed in the relevant professions in US. Researchers have proved that the impact of digitalisation on the profession cannot be considered solely as destructive, or rather it should be called transformative.

However, when experts study the impact of digitalisation on the employment structure, they often focus on the destructive effects – the probability of replacing human labour with machines (Brynjolfsson and McAfee, 2014; Acemoglu and Restrepo, 2019).

Indeed, one of the main threats to the introduction of digital technologies is associated with a reduction in employment in certain professions (in particular, medium and low-skilled). At the same time, digital employment platforms can increase the number of non-standard jobs. We are talking about short-term contracts, part-time employment options,

low-paid jobs). At the same time, there is a possibility of an increase in the gender wage gap. On the other hand, most digital products and services are aimed at helping society solve certain problems and improve the quality of life of the population. For example, e-health makes it possible to make a certain contribution to the problem of population aging and rising social costs (OECD, 2017). It is for this reason that the positive and negative side effects of digital changes in the labour market and employment should be highlighted. Changes in employment can spread both horizontally (within the industry) and vertically (supply chain effects) (United Nations, 2019b).

2 Spillover-the effect of social and regional asymmetry in the use of digital technologies

This spillover effect is a manifestation of digital inequality resulting from uneven implementation and use of digital technologies within countries and regions (Reimer, 2016; Greenstein and Prince, 2006; Van Ark, 2014; Karpunina et al., 2019c).

OECD experts pointed to the emergence of digital gaps between individuals, households, businesses and regions in terms of access to the internet and the use of digital technologies in daily life and professional activities. On the one hand, access to the internet and its use, the nature of the technologies being implemented are determined by the level and quality of life of the population, income and material capabilities of business, as well as needs for the realisation of human potential and targets for long-term development, and, on the other hand, by the implemented state policy in the field of digital development (Ragnedda and Muschert, 2013).

Thus, there are two types of asymmetries from the use of digital technologies. Social vertical asymmetry manifests itself in the form of a gap in the realisation of development opportunities. The regional horizontal is identified in the form of differences in the level of socio-economic development of the regions. Both types of asymmetry should be attributed to the side effects of the digital economy (Hargittai, 2002; Stiakakis et al., 2009; Novak and Hoffman, 2000).

3 Information risks as a spillover effect of the digital economy

In the digital economy, information risks become an integral part of objective reality. They affect the activities of individuals, businesses, and the national economy. They cause direct economic and image damage (McKinsey and Company, 2018). The OECD report says that the digital economy development requires addressing the risk of failures in areas such as digital privacy, security and trust (OECD, 2015).

Individuals often face information threats. They may be negatively affected by the leakage of personal data, be exposed to fraudulent transactions with bank cards, and their digital devices are at risk of infection with spam and viruses, or unauthorised access. For example, in 2018, 27.9% of users suffered as a result of loss of information, violation of its integrity and confidentiality, or experienced hardware failures (Kevesh et al., 2019).

Competition conditions provoke the emergence of cyber attacks and cyber espionage in the industry to steal business information through faulty nodes and information systems, access to web servers, the use of malicious software, phishing, and others. They cause direct financial damage or loss of business reputation of the business company (Molchan et al., 2019).

According to Sobers (2019), 31% of cyber attacks are committed against the operational technological infrastructure of companies. To do this, attackers use virus

programs (there is a known case of the spread of the Wannacry virus in 2017, which caused damage to 400,000 machines in 150 countries, and companies lost \$ 4 billion).

Information threats undermine the integrity and make public administration systems vulnerable. By undermining the natural information structure of markets, they cause an increase in unproductive costs, including the creation of security systems or the elimination of damage from cyber attacks (Karpunina et al., 2019b). The implementation of information risks both horizontally and vertically certainly reduces the potential benefits of digitalisation.

4.3 Conceptual framework for evaluating the spillover effects of the digital economy

The spillover effects of investment are estimated using a simulation method based on the Cobb-Douglas production function, which shows the functional relationship between the volume of effectively used factors of production and the output achieved (Javorcik, 2004; Stančík, 2007; Fedorova et al., 2016). Such calculations are performed at the level of an individual company, industry, or region.

The impact of the spillover effect of investment in R&D on the knowledge stock and economic growth is estimated using econometric modelling (Griliches, 1992).

The assessment of socio-economic efficiency of the use of ICT is carried out by an integral and expert method, which consists of a point evaluation of parameters and calculation of the integral efficiency coefficient (Adzhemov et al., 2015; Kuzovkov, 2016).

In our opinion, these approaches to the digital economy are not applicable due to the lack of statistical data for assessment on an international scale, as well as in the context of individual countries and regions.

In this regard, we consider it appropriate to use the statistical method of variance (a measure of the spread of a value relative to its mathematical expectation) and the average square deviation to assess the spillover effects of the digital economy. The initial indicators in the calculations are: Unemployment rate – to assess the spillover effect of changes in the labour market and employment (TakeProfit, 2020); HDI, adjusted for inequality in access to technology – to assess the spillover effect of social and regional asymmetries in the use of digital technologies (United Nations, 2019a); Cybersecurity Index – to assess information risks as a spillover effect of the digital economy (ITU, 2019).

The accuracy of calculations and the objectivity of the results obtained will depend on the accuracy of statistical data provided by national statistical agencies and international organisations.

4.4 The implementation of the state policy of digital development based on the assessment and management of the spillover effects of digitalisation

The implementation of the state policy of digital development based on the assessment and management of the spillover effects of digitalisation will allow countries to provide a leading breakthrough at the stage of formation of a new configuration of the global economy (Pilipchuk et al., 2024; Semenova and Martínez Santoyo, 2024; Marin et al., 2022). This policy will be focused on continuous monitoring of market signals and ensuring maximum adaptability of the economic system to changes.

This is particularly relevant in the context of the 2020 pandemic (Karpunina et al., 2021; Gukasyan et al., 2022). The pandemic has not only caused direct epidemiological damage to States, increasing the morbidity and mortality of the population. It has created the conditions for a global economic downturn. At the same time, for the first time in history, the introduced lockdowns provoked the intensification of digitalisation, the growth of information insecurity, the transformation of forms of employment and the transfer of numerous activities of the population to online mode.

The measures implemented by the Governments of various countries, for the most part, had a fragmented effect and did not help prevent a recession (Marin et al., 2022; Ilyushin, 2022; Semenova et al., 2021). However, it was the transfer of enterprises to the information channel, the expansion of digital infrastructure in connection with the needs of the population to remain involved in socio-economic processes in quarantine conditions that became effective measures to save the economy. The pandemic has created the prerequisites for launching changes related to the processes of organising production, promoting goods and services, transforming the relationship between consumers and producers, the emergence of new models of responsible (Pilipchuk et al., 2024).

Conscious management of digitalisation in various countries during this critical period can ensure that developing countries gain new competitive advantages, outstrip developed countries, and, as a result, redistribute the centers of economic leadership from developed countries to developing economies.

That is why building a well-thought-out government policy of digital development, based on managing the side effects of digitalisation, can provide developing economies with new opportunities to ensure leadership positions.

5 Conclusions

The paper reveals the specifics of the effects obtained from the digital economy development. The direct effects of investing in digital economy come in the form of GDP growth, increased productivity, expanded markets, and additional profits.

The authors studied the spillover effects of the digitalisation. It is proved that spillover effects can have both positive and negative effects on the national economy.

The authors investigated approaches to estimating spillover effects and proposed a variant of their estimation based on the statistical method of variance and mean square deviation.

The authors justified the need to implement the methodology for assessing the spillover effects of digitalisation in the mechanism of formation and implementation of the state policy of digital development.

References

- Acemoglu, D. and Restrepo, P. (2019) *The Wrong Kind of AI? Artificial Intelligence and the Future of Labor Demand*, IZA Discussion Paper, 12292, Institute of Labor Economics, Bonn.
- Adzhemov, A., Buydinov, E. and Kuzovkov, V. (2015) 'Application of the method expert analytical to justify the selection of effective innovation in satellite communications', *Telecommunications*, Vol. 1, pp.27–30.

- Akerman, A., Gaarder, I. and Mogstad, M. (2015) 'The skill complementarity of broadband internet', *The Quarterly Journal of Economics*, Vol. 130, No. 4, pp.1781–1824.
- Atkinson, R., Castro, D. and Ezell, S. (2009) *The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America*, The Information Technology and Innovation Foundation, Washington DC.
- Barefoot, K., Curtis, D., Jolliff, W., Nicholson, J. and Omohundro, R. (2018) *Defining and Measuring the Digital Economy*, <https://www.bea.gov/research/papers/2018/defining-and-measuring-digital-economy> (Accessed 21 January, 2023).
- Brynjolfsson, E. and McAfee, A. (2014) *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, WW Norton & Company, New York, London.
- Buckley, P., Clegg, J. and Wang, C. (2007) 'Is the relationship between inward FDI and spillover effects linear? an empirical examination of the case of China', *Journal of International Business Studies*, Vol. 38, No. 3, pp.447–459.
- Carlino, G. (2001) 'Knowledge spillovers: cities' role in the new economy', *Business Review (Federal Reserve Bank of Philadelphia)*, Vol. 7, No. Q4, pp.17–26.
- Chengqi, W. and Zhongxiu, Z. (2008) 'Horizontal and vertical spillover effects of foreign direct investment in Chinese manufacturing', *Journal of Chinese Economic and Foreign Trade Studies*, Vol. 1, pp.8–20.
- Cherepovitsyn, A. and Solovyova, V. (2022) 'Prospects for the development of the Russian rare-earth metal industry in view of the global energy transition-a review', *Energies*, Vol. 15, No. 1, p.387, doi: 10.3390/en15010387.
- Coe, D., Helpman, E. and Hoffmaister, A. (2009) 'International R & D spillovers and institutions', *European Economic Review*, Vol. 53, pp.723–741.
- Crandall, R., Lehr, W. and Litan, R. (2007) *The Effects of Broadband Deployment on Output and Employment: A Cross Sectional Analysis of U.S. Data*, <http://www.brookings.edu/research/papers/2007/06/labor-crandall> (Accessed 21 January, 2023).
- Dudina, A., Nikolaichuk, L. and Shabalov, M. (2021) 'Increasing the efficiency of Russian uranium mining enterprises in conditions of excessive supply', *Proceedings of the E3S Web of Conferences, Topical Issues of Rational Use of Natural Resources*, Vol. 266, p.06006, doi: 10.1051/e3sconf/202126606006.
- Edward, G., Kallal, H., Scheinkman, J. and Shleifer, A. (1992) 'Growth in cities', *Journal of Political Economy*, Vol. 100, pp.1126–1153.
- Fedorova, E. and Barikhina, Y. (2015) 'Assessing horizontal and vertical spillover effects from foreign direct investment in Russia', *Voprosy Ekonomiki*, Vol. 3, pp.46–60 (In Russ.).
- Fedorova, E., Korkmazova, B. and Muratov, M. (2016) 'Spillover effects of the Russian economy: regional specificity', *Economy of Region*, Vol. 1, pp.139–149 (In Russ.).
- Filatova, I., Nikolaichuk, L., Zakaev, D. and Ilin, I. (2021) 'Public-private partnership as a tool of sustainable development in the oil-refining sector: Russian case', *Sustainability*, Vol. 13, No. 9, p.5153.
- Fossen, F. and Sorgner, A. (2019) 'Mapping the future of occupations: transformative and destructive effects of new digital technologies on jobs', *Foresight and STI Governance*, Vol. 13, No. 2, pp.10–18.
- Fraymovich, D.Y., Konovalova, M.E., Roshchektaeva, U.Y., Karpunina, E.K. and Avagyan, G.L. (2022) 'Designing mechanisms for ensuring the economic security of regions: countering the challenges of instability', *Towards an Increased Security: Green Innovations, Intellectual Property Protection and Information Security*, Lecture Notes in Networks and Systems, Vol. 372, Springer, Cham, pp.569–581.
- Gillett, S., Lehr, W., Osorio, C. and Sirbu, M. (2006) *Measuring Broadband's Economic Impact*, Technical Report 99-07-13829, U.S. Department of Commerce 1401 Constitution Ave, N.W., Washington DC.
- Gordon, R. (2012) *Is US Economic Growth over? Faltering Innovation Confronts the Six Headwinds*, National Bureau of Economic Research, Cambridge, MA.

- Greenstein, S. and Prince, J. (2006) *The Diffusion of the Internet and the Geography of the Digital Device in the United States*, Working Paper, Institute for Policy Research, Northwestern University, Evanston, Ill.
- Griliches, Z. (1992) 'The search for R & D spillovers', *Scandinavian Journal of Economics*, Vol. 94, pp.29–48.
- Gukasyan, Z.O., Tavbulatova, Z.K., Aksenova, Z.A., Gasanova, N.M. and Karpunina, E.K. (2022) 'Strategies for adapting companies to the turbulence caused by the covid-19 pandemic', *Business 4.0 as a Subject of the Digital Economy*, Springer Cham, pp.639–645.
- Hargittai, E. (2002) *Second Level Digital Divide: Differences in People's Online Skills*, <http://www.eszter.com/research/pubs/hargittai-secondleveldd.pdf> (Accessed 21 January, 2023).
- Huawei and Oxford Economics (2017) *Digital Spillover. Measuring the True Impact of the Digital Economy*, <https://www.huawei.com/minisite/gci/en/digital-spillover/index.html> (Accessed 21 January, 2023).
- IDC (2020) *IDC – Global ICT Spending Forecast 2020 – 2023*, <https://www.idc.com/promo/global-ict-spending/forecast> (Accessed 21 January, 2023).
- Ilyushin, Y.V. (2022) 'Development of a process control system for the production of high-paraffin oil', *Energies*, Vol. 15, p.6462, doi: 10.3390/en15176462.
- ITU (2019) *Global Cybersecurity Index*, <https://www.itu.int/en/ITU-D/Cybersecurity/Pages/global-cybersecurity-index.aspx> (Accessed 21 January, 2023).
- Javorcik, B. (2004) 'Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages', *American Economic Review*, Vol. 94, No. 3, pp.605–627.
- Jorgensen, D., Ho, M., Samuels, J. and Stiroh, K. (2005) *Productivity Growth in the New Millennium and Its Industry Origins*, The Institute for Quantitative Social Science and the Federal Reserve Bank of New York.
- Karpunina, E., Derkacheva, E., Lisova, E., Nazarchuk, N. and Abalakin, A. (2019a) 'Social orientation of the digital economy: a critical analysis of information development concepts', *Proceedings of the 34th IBIMA Conference «Vision 2025: Education Excellence and Management of Innovations Through Sustainable Economic Competitive Advantage»*, 13–14 November, Madrid, Spain, pp.4090–4099.
- Karpunina, E., Gorbunova, O., Moiseev, S. and Cheremisina, T. (2019b) 'Resistance is not hopeless... regarding the policy of countering information threats of economic security', *Proceedings of the 33rd International Business Information Management Association Conference (IBIMA): Education Excellence and Innovation Management Through Vision 2020*, 10–11 April, 2019, Granada, Spain, pp.2679–2686.
- Karpunina, E., Yurina, E., Kuznetsov, I. and Dubovitski, A. (2019c) 'Growth potential and economic security threats in terms of digital economy ecosystem', *Proceedings of the 33rd International Business Information Management Association Conference (IBIMA): Education Excellence and Innovation Management Through Vision 2020*, 10–11 April, 2019, Granada, Spain, pp.2669–2678.
- Karpunina, E.K., Butova, L.M., Sobolevskaya, T.G., Badokina, E.A. and Pliusnina, O.V. (2021) 'The impact of the covid-19 pandemic on the development of Russian national economy sectors: analysis of dynamics and search for stabilization measures', *Innovation Management and Information Technology Impact on Global Economy in the Era of Pandemic*, Springer. Cham, pp.1213–1226.
- Katz, R. (2017) *Social and Economic Impact of Digital Transformation on the Economy*, https://www.itu.int/en/ITU-D/Conferences/GSR/Documents/GSR2017/Soc_Eco_impact_Digital_transformation_finalGSR.pdf (Accessed 21 January, 2023)
- Katz, R. and Callorda, F. (2017) 'Estimación del impacto económico del crecimiento del ecosistema digital en américa latina', *Proceedings of the Tenth CPR-Latam Conference*, 23 June, Cartagena de Indias.

- Kesidou, E. and Szirmai, A. (2007) 'Local knowledge spillovers, innovation and economic performance in developing countries: empirical evidence from the Uruguay software cluster', *Proceedings of the UNU-MERIT Conference on 'Micro Evidence on Innovation in Developing Economies'*, 31 May–1 June, Maastricht (Netherlands).
- Kevesh, M., Kovaleva, G. and Kotsemir, M. (2019) *Public Confidence in Network Technologies and Services*, https://issek.hse.ru/data/2019/06/20/1488856771/NTI_N_133_20062019.pdf (Accessed 21 January, 2023).
- Kim, J. and Lee, H. (2004) 'Embodied and disembodied international spillovers of R & D in OECD manufacturing industries (short survey)', *Technovation*, Vol. 24, pp.359–368.
- Kuzovkov, A. (2016) 'Integral expert method for evaluating the socio-economic efficiency of using infocommunication technologies', *Electronic Scientific Journal "Century of Quality"*, Vol. 2, pp.88–99 (In Russian).
- Kuzovkov, A., Tkachenko, D. and Sharavova, M. (2019) 'The synergistic character of socio-economic efficiency of digital development and digital technologies', *Economy and Quality of Communication Systems*, Vol. 2, pp.21–30 (In Russian).
- Marin, E.A., Ponomarenko, T.V., Vasilenko, N.V. and Galevskiy, S.G. (2022) 'Economic evaluation of projects for development of raw hydrocarbons fields in the conditions of the northern production areas using binary and reverting discounting', *Sever i Rynok: Formirovanie Ekonomicheskogo Poradka*, Vol. 25, No. 3, pp.144–157.
- McKinsey and Company (2018) *Digital and Risk: A New Posture for Cyberrisk in a Networked World*, <https://www.mckinsey.com/business-functions/risk/our-insights/a-new-posture-for-cybersecurity-in-a-networked-world> (Accessed 21 January, 2023).
- Molchan, A., Karpunina, E., Kochyan, G., Petrov, I. and Velikanova, L. (2019) 'Effects of digitalization: new challenges for economic security systems', *Proceedings of the 34th IBIMA Conference «Vision 2025: Education Excellence and Management of Innovations Through Sustainable Economic Competitive Advantage»*, 13–14 November, Madrid, Spain, pp.6631–6640.
- Nikiforova, V.D. and Nikiforov, A.A. (2021) 'State regulation of blockchain technology in the sphere of payments and financial services', *Socio-Economic Systems: Paradigms for the Future*, Springer, Cham, pp.73–80, doi: 10.1007/978-3-030-56433-9_9.
- Nikiforova, V.D., Achba, L.V., Nikiforov, A.A. and Kovalenko, A.V. (2020) 'Dialectics of the processes of digitization of the socio-economic system', *Lecture Notes in Networks and Systems*, Vol. 87, Springer, Cham, pp.690–697, doi: 10.1007/978-3-030-29586-8_80.
- Novak, T. and Hoffman, D. (2000) *Bridging the Digital Divide: The Internet of Race on Computer Access and Internet Use*, <http://www2000.ogsm.vanderbilt.edu/digital.divide.html> (Accessed 21 January, 2023).
- OECD (2015) *Countries should Address Disruptive Effects of the Digital Economy*, <https://www.oecd.org/internet/countries-should-address-disruptive-effects-of-the-digital-economy.htm> (Accessed 21 January, 2023).
- OECD (2017) *Digital Economy Outlook*, <https://www.oecd-ilibrary.org/docserver/9789264276284-en.pdf?expires=1597952241&id=id&accname=guest&checksum=923643B6CC90ADE60B4D3B168FE36993> (Accessed 21 January, 2023).
- OECD (2019) *Measuring Tax Support for R & D and Innovation*, <http://www.oecd.org/sti/rd-tax-stats.htm> (Accessed 21 January, 2023).
- OECD (2020) *ICT Access and Usage by Households and Individuals*, https://stats.oecd.org/Index.aspx?DataSetCode=ICT_BUS (Accessed 21 January, 2023).
- Pearson (2016) *Rating of the Effectiveness of National Education Systems*, <https://gtmarket.ru/ratings/global-index-of-cognitive-skills-and-educational-attainment> (Accessed 21 January, 2023).
- Pilipchuk, N.V., Aksenova, Z.A., Lupacheva, S.V., Markova, O.M. and Tamov, R.M. (2024) 'Digital development of Russian regions: prospects and contradictions in a period of turbulence', *Advances in Science, Technology and Innovation*, Part F2356, pp.393–398.

- Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2003) 'Networking and innovation: a systematic review of the evidence', *International Journal of Management Review*, Vol. 5, No. 6, pp.37–168.
- Ponomarenko, T., Marin, E. and Galevskiy, S. (2022) 'Economic evaluation of oil and gas projects: justification of engineering solutions in the implementation of field development projects', *Energies*, Vol. 1, No. 9, p.3103, doi: 10.3390/en15093103.
- Ragnedda, M. and Muschert, G. (2013) *The Digital Divide: The Internet and Social Inequality in International Perspective*, Routledge.
- Reimer, D. (2016) *Digital Transformation 2016*, <http://denreymmer.com/digitaltransformation-2016> (Accessed 21 January, 2023).
- Royal Academy of Engineering (2018) *Increasing R & D Investment: Business Perspectives*, <https://www.raeng.org.uk/publications/reports/increasing-r-d-investment-business-perspectives> (Accessed 21 January, 2023)
- Samylovskaya, E., Makhovikov, A., Lutonin, A., Medvedev, D. and Kudryavtseva, R.E. (2022) 'Digital technologies in arctic oil and gas resources extraction: global trends and Russian experience', *Resources*, Vol. 11, No. 3, p.19.
- Semenova, T. and Martínez Santoyo, J.Y. (2024) 'Economic strategy for developing the oil industry in Mexico by incorporating environmental factors', *Sustainability*, Vol. 16, p.36, doi: 10.3390/su16010036.
- Semenova, T., Al-Dirawi, A. and Al-Saadi, T. (2021) 'Environmental challenges for fragile economies: adaptation opportunities on the examples of the arctic and Iraq', *Agronomy*, Vol. 12, doi: 10.3390/agronomy12092021.
- Shideler, D., Badasyan, N. and Taylor, L. (2007) 'The economic impact of broadband deployment in Kentucky', *Regional Economic Development*, Vol. 3, pp.88–118.
- Sobers, R. (2019) *6.0 Must-Know Cybersecurity Statistics for 2019*, <https://www.varonis.com/blog/cybersecurity-statistics/> (Accessed 21 January, 2023).
- Stančík, J. (2007) *Horizontal and Vertical FDI Spillovers: Recent Evidence From the Czech Republic*, <https://www.cerge-ei.cz/pdf/wp/Wp.340.pdf> (Accessed 21 January, 2023).
- Stiakakis, E., Kariotellis, P. and Vlachopoulou, M. (2009) *From the Digital Divide to Digital Inequality: A Secondary Research in the European Union*, e-Democracy 2009, LNICST 26, pp.43–54.
- TakeProfit (2020) *Ranking of Countries by Unemployment Rate*, <https://take-profit.org/statistics/unemployment-rate/> (Accessed 21 January, 2023)
- Teece, D. (1977) 'Technology transfer by multinational firms: the resource cost of transferring technological know-how', *Economic Journal*, Vol. 87, No. 2, pp.242–261.
- UNESCO Institute for Statistic (2020) *How Much Does your Country Invest in R & D*, <http://uis.unesco.org/apps/visualisations/research-and-development-spending/> (Accessed 21 January, 2023).
- United Nations (2019a) *2019 Human Development Index Ranking*, <http://hdr.undp.org/en/content/2019-human-development-index-ranking> (Accessed 21 January, 2023).
- United Nations (2019b) *Digital Economy Report 2019: Value Creation and Capture: Implications for Developing Countries*, https://unctad.org/en/PublicationsLibrary/der2019_en.pdf (Accessed 21 January, 2023).
- Van Ark, B. (2014) 'Productivity and digitalization in Europe: paving the road to faster growth', *Communications and Strategies*, Vol. 1, No. 100, pp.107–124.
- Varian, H., Litan, R., Elder, A. and Shutter, J. (2002) *The Net Impact Study: The Projected Economic Benefits of the Internet in the United States, United Kingdom, France and Germany*, http://www.itu.int/wsis/stocktaking/docs/activities/1288617396/NetImpact_Study_Report_Brookings.pdf (Accessed 21 January, 2023).

- Volodina, E., Kuzovkova, T. and Narukavnikov, A. (2011) 'Compensation for the use of the radio frequency spectrum as an economic method of effective management of a limited natural resource', *Vestnik RAEN*, Vol. 11, pp.103–108 (In Russian).
- Wang, C. and Zhao, Z. (2008) 'Horizontal and vertical spillover effects of foreign direct investment in Chinese manufacturing', *Journal of Chinese Economic and Foreign Trade Studies*, Vol. 1, No. 1, pp.8–20.
- Wang, M., Fang, C. and Huang, L. (2009) 'International knowledge spillovers and wage inequality in developing countries', *Economic Modelling*, Vol. 26, pp.1208–1214.
- World Bank (2020) *GDP (Current US\$)*, <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD> (Accessed 21 January, 2023).