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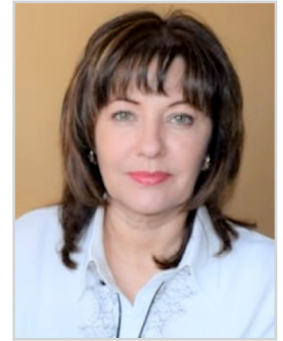
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# Digital economy as a factor in increasing the competitiveness of countries and industries: a quantitative analysis

**Abstract**
The paper touches upon various aspects of the digital economy and its stages of its formation. The authors of the research present relevant data on the development of the digital economy both in the world and the Russian Federation, and forecast some of the consequences of the introduction of digital technologies based on quantitative analysis and modeling. The authors have analyzed several business models that appeared after the spread of large databases, artificial intelligence, machine learning, and other digital technologies. Based on the analysis as of 2020, it has been concluded that transition to digital technologies enhances the competitiveness of national economies.
**Keywords:** Digital Economy; Competitiveness; Digital Technologies; IT Technologies; Business Models; Digitalization; Digital Platforms; Digital Development
**JEL Classifications:** A10; E37; M21

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**Цифрова економіка як фактор підвищення конкурентоспроможності країн і галузей промисловості: кількісний аналіз**

**Анотація.** У статті висвітлюються різні аспекти становлення цифрової економіки, а також різні підходи до тлумачення цього явища. Представлено дані про розвиток цифрової економіки як за кордоном, так і в Російській Федерації в 2020 р., що дозволило спрогнозувати деякі наслідки впровадження цифрових технологій. авторами статті було проаналізовано бізнес-моделі, які з'явилися після поширення великих баз даних, штучного інтелекту, машинного навчання та інших цифрових технологій. Зроблено висновок, що перехід до цифрових технологій підвищує конкурентоспроможність національних економік.
**Ключові слова:** цифрова економіка; конкурентоспроможність; цифрові технології; інформаційні технології; бізнес-моделі; діджиталізація; цифрові платформи; цифровий розвиток.

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**Цифровая экономика как фактор повышения конкурентоспособности стран и отраслей промышленности: количественный анализ**

**Аннотация.** В статье рассматриваются различные аспекты формирования цифровой экономики, а также трактовки данного понятия. Приведеные авторами статьи данные о развитии цифровой экономики как за рубежом, так и в Российской Федерации в 2020 г., позволили спрогнозировать некоторые последствия внедрения цифровых технологий. Авторы статьи провели анализ бизнес-моделей, появившихся после распространения больших баз данных, искусственного интеллекта, машинного обучения, а также других цифровых технологий. На основании результатов анализа был сделан вывод о том, что переход на цифровые технологии повышает конкурентоспособность национальных экономик.
**Ключевые слова:** цифровая экономика; конкурентоспособность; цифровые технологи; информационные технологии; бизнес-модели; диджитализация; цифровые платформы; цифровое развитие.

## 1. Introduction

The proliferation of digital technologies over a long period determines the development paths of the economy and society and has already led to dramatic changes in people's lives more than once. The formation of the digital economy is one of the priority areas for most countries - economic leaders, including the USA, Great Britain, Germany, Japan, etc. As a rule, they are characterized by a long period of implementation of the «digital development agenda» and the continuity of priorities - from building a basic information and communication infrastructure to the formation of a coordinated policy in this area and support programs for the widespread adoption of digital technologies.

In recent years, another wave of transformation of business and social activity models has been unfolding, caused by the advent of a new generation of digital technologies, which, due to the scale and depth of influence, are called «end-to-end» - artificial intelligence, robotics, the Internet of things, wireless technologies and some others (Panfilov & Kabanov, 2016; Ivanov et al., 2017; National Digital Economy Development Index, 2018).

Their implementation is estimated to be able to increase labor productivity in companies by 40%. In the near future, it is the effective use of new digital technologies that will determine the international competitiveness of both individual companies and entire countries that form the infrastructure and legal environment for digitalization.

Today, at a new stage in the development of digital technologies, one of the main challenges is the exponential increase in the quantity, quality and diversity of interconnections between organizations, citizens and socio-economic systems, accompanied by spasmodic dynamics in the number of transactions of accessed data and leading to more complex and synchronized (Akaev & Sadovnichii, 2021).

In international practice, a harmonized definition of the digital economy has not yet developed. In most foreign sources, the description of the digital economy focuses on technologies and related changes in the methods of interaction of economic agents. In this case, either specific types of technologies or some form of change in economic processes may be mentioned. The definition of digital economy is replaced by a list of areas of its influence on the economy and the social sphere.

## 2. Method

Digitalization provides fundamental transformations in all spheres of human life and activity (Figure 1). Technology is becoming not only an engine for the development of new industries, but also gaining important social roles, making a significant contribution to solving society's problems, such as aging populations, social stratification, environmental problems and climate change. With the help of advanced science and technology, an «intelligent» society arises, based on new values of orientation to human needs, flexibility, creativity. Under the influence of digitalization, the labor market, healthcare, education, and spatial development are radically changing (Lapidus 2018b; Skolkovo, 2018; Jiang, 2021).
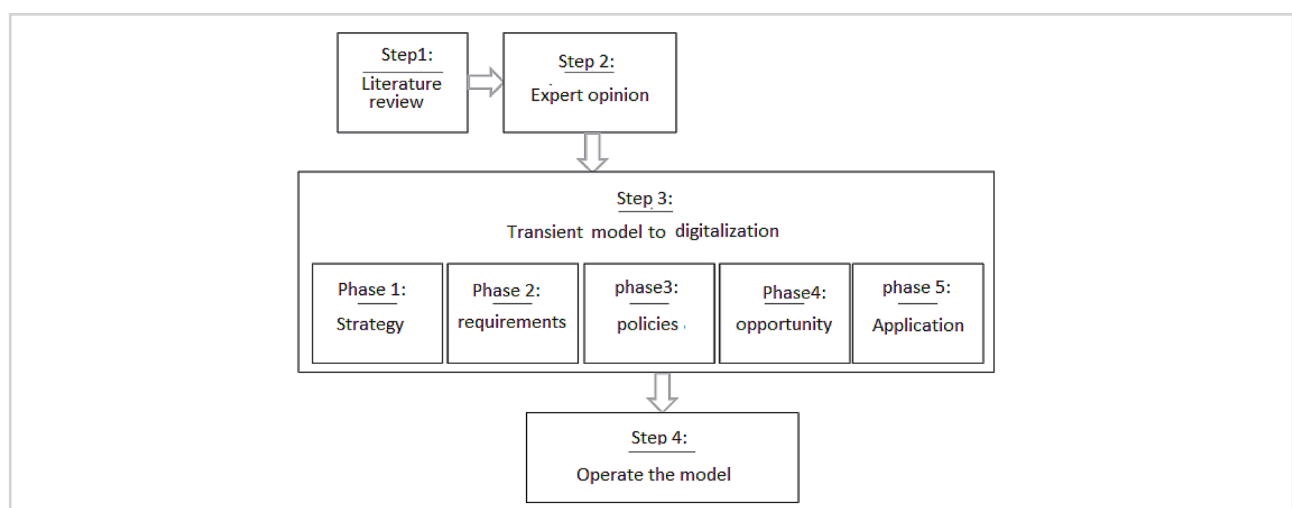


Figure 1:
**Methodology of transition model to digital economy**
Source: Compiled by the authors

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### 2.1. Global Competitiveness Index (GCI)

Competitiveness is defined as a set of institutions, policies and factors that determine the level of productivity of an economy and regulate the level of prosperity of a country. Based on the original view of the Schwab class in 1979, since 2005 the World Economic Forum has published the Global Competitiveness Index, developed by Javier Sala Martin in collaboration with the Assembly. Since the update in 2007, its methodology has remained largely unchanged. GCI is a combination of 114 indicators that consider concepts that are important for productivity. These indicators are grouped into 12 pillars: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and education, product market efficiency, labor market efficiency, financial market development, technological readiness, market size, evolution Business and innovation. These pillars fall into three sub-indicators, which are in the context of three stages of development: basic needs, performance enhancers, and factors of innovation and evolution. In calculating the overall index, these three sub-indices are given different weights based on the development stage of each economy, which is obtained through the per capita GDP and the share of raw material exports. The GCI includes statistical data from reputable international agencies, in particular the International Monetary Fund, UNESCO, and the World Health Organization, as well as data from opinion polls conducted by executives at the World Economic Forum (Martseniuk et al., 2020).

### 2.2. Global Innovation Index

Innovation is defined as the adoption of an idea, behavior, system, policy, program, means, process, product, or service that is new to the organization (Damanpour, 1992; Phillips, 1997). If for Domanepour, organizational innovation is related to all parts of the organization and therefore includes all types of innovation, innovation can often be divided into two categories: technological and organizational innovation. For example, Philips separates technological and non-technological innovation and puts new strategies and changes to management techniques or organizational structures in the second category.

The data panel method is used to estimate the relationship between the two variables of innovation and competitiveness. The model used is in accordance as:

$$GCI_{ti} = C_{it} + GII_{it} + U_{it}, \tag{1}$$

where:
$GCI_{ti}$ indicates the competitiveness index for country $i$ at time $t$;
$C_{it}$ is a fixed component expression in the model;
$GII_{it}$ is the Innovation index for country $i$ at time $t$;
$U_{it}$ is a component of the error in the model.

### 3. Results

An economy in which, thanks to the development of digital technologies, there is an increase in labor productivity, competitiveness of companies, lower production costs, creation of new jobs, reduction of poverty and social inequality.

The unified concept of the digital economy is still absent in Russia. The key statements that are available include the following:
- the economy of a new technological generation (Message from the President of the Russian Federation to the Federal Assembly);
- economic activity in which the key factor in production is digital data; processing large volumes of this data and using the results of their analysis compared to traditional forms of management can significantly increase the efficiency of various types of production, equipment, storage, sale, delivery of goods and services (Development Strategy of the Information Society of the Russian Federation for 2017-2030) (Lapidus, 2018a). Based on many years of experience in the formation of fundamentally new branches of statistics related to science, technology and innovation, we propose the following interrelated definitions for the purposes of statistical measurement of the development of the digital economy:
- digital economy - activities to create, disseminate and use digital technologies and related products and services;
- digital technologies - technologies for the collection, storage, processing, search, transmission and presentation of data in electronic form.

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The F-Limer and Hausman statistic tests are used to select the estimation method based on panel data or the combined data method (Table 1). This test was carried out over the year 2020. In this test, Hypothesis H0 is the method of estimation based on composite data and Hypothesis H1 is the method of estimation based on panel data.

Here the pattern is estimated. Before estimating the model, it is necessary to test the significance of all the variables used in the estimates, because the anonymity of the variables, both for time series data and panel data, causes a false regression problem. Contrary to what is common with time series data, Dickey-Fuller and Generalized Dick-Fuller (ADF) tests cannot be used for panel mana test for panel data. Other tests can be used to do this, including the Levin, Lane, and Chow (LLC) tests (Table 2), the Em, Boys and Sheen test (ISP), the Bertong test, and the Fisher test. ADF. The results shown in Table 3 show the significance of all model variables. In these tests, H0 hypothesis is based on anonymity and H1 hypothesis is based on the meaning of variables.

Finally, according to the results of the study of the significance of the research variables, it shows the significance of all variables at the level of 5%. This template has been tested using EViews software.

The findings of Table 3 show that the innovation index in selected countries has positive and significant effects on the competitiveness index in these countries. It is also observed that this effect is statistically significant at the level of 5%. In general, it can be concluded that the growth of the innovation index in selected countries has been able to greatly enhance the competitiveness of these countries.

## 4. Discussion

Digitalization requires the formation of new competencies in the labor market, which entails the restructuring of the entire education system. Transnational forms of education are developing (cross-border education), and a highly competitive environment is being formed in the rapidly growing global educational market, where both traditional (USA, UK) and new providers of educational services from East and Southeast Asia, Eastern Europe, and the Middle East coexist. The number of students entering universities in another country after graduation is growing by 10% per year and will reach 8 million by 2021. By 2025, their share will reach 25% of the total number of people employed in the world. The key motivating factor for them is the possibility of personal development (including those not related to work), and not just career growth and the level of wages, as in previous generations. Accordingly, companies have to change the tactics of hiring and retaining personnel, taking into account the values of the new generation (Kabanov et al., 2020, Zhadan, 2013).

At the same time, the «smarter» access devices become, the higher the owner's vulnerability level. The spread of the Internet of things will make a person virtually transparent to any interested parties and structures, which, in turn, creates a demand for the development of information security technologies and cybercrime technologies (Zhadan, 2019).

Table 1:
**F-Limer and Hausman statistic tests**

| Test | T statistics | Possibility |
|---|---|---|
| F-limer | 0.001 | 320.7669 |
| Hausman | 0.005 | 116/8137 |

Source: Compiled by the authors

Table 2:
**Evaluation of research variables (LLC)**

| Variable | LLC | Possibility | Significance |
|---|---|---|---|
| GCI | -9.52 | 0.0001 | confirmed |
| GII | -7.45 | 0.0001 | confirmed |

Source: Compiled by the authors

Table 3:
**Estimation of research model**

| Variable | SD | T statistic | Possibility |
|---|---|---|---|
| GCI | confirmed | 37.001 | 0.0001 |
| GII | confirmed | 2.501 | 0.0130 |

Source: Compiled by the authors

The digital economy sets the path for the transformation of traditional sectors of the economy, the emergence of new markets and niches. High-speed processing of big data becomes a key source of value creation, as transactions occur in real time and often at the same time. Big data and AI analysis technologies help find new sources of value creation through the study of digital portraits of consumers and patterns of their economic behavior. Customer data is becoming the main asset of digital companies, and access to large arrays of them increases the assessment of market value.

The proliferation of Internet of things, big data, artificial intelligence and machine learning technologies and other digital technologies has led to the development of the following categories of business models:

- digital platforms that provide direct interaction between sellers, buyers and supplier partners, minimizing transaction costs and expanding the opportunities for joint consumption of goods and services. Depending on the product and the market segment, the platforms can be communication, social, media, search, operational and controlled, service, sharing, product, transaction, etc.;
- «as a service» - service business models based on the use of resources instead of owning them (among them Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS), etc.). Today, there are all new varieties of service models, including Robots-as-a-Service, City-as-a-Service. Service models contribute to the personalization of goods and services, allowing the client to consume the necessary product in the volumes he needs to achieve the desired result;
- business models based on pricing based on the achievement of outcomes (outcome based models) and the effect for the client, including based on the consumption of complex products and services. Such business models, by analogy with service ones, are often called Product-as-a-Service (PaaS);
- to crowdsourcing models based on attracting external resources (money, people, ideas, etc.) for the implementation of business processes - the introduction of innovations, product development, production, marketing and sales, etc.;
- business models based on the monetization of personal data of customers, when services free of charge for users sell their data on other consumer segments.

New digital technologies are expanding business opportunities to optimize many processes and improve the quality of decision-making. So, the Internet of things and cloud computing optimize the collection and storage of data, and the technologies and methods of machine learning and AI allow them to be deeply processed, build behavior algorithms and predictive models. In retail, a new type of business model is associated with the transformation of e-commerce into a-commerce (automated commerce), in which the seller builds algorithms that describe the customer's consumption model, and then automatically delivers the goods to him based on the predicted need. Predictive analytics technologies are aimed at constructing algorithms that describe the consumption of products and services, and automation based on forecasts of the processes of production and delivery of goods to customers with the participation of partners (Kabanov et al., 2019b). Blockchain technology allows decentralizing the processes of data collection, transmission and storage, thereby increasing the reliability of transactions and promoting the development of platform technologies for interaction with partners and consumers. So, INS Ecosystem plans to launch a platform for direct interaction between manufacturers and consumers, bypassing traditional retail, based on deep personalization of offers and using blockchain technologies. Already 7 of the top 20 global FMCG manufacturers (Fast Moving Consumer Goods) are collaborating with the platform. Virtual and augmented reality contributes to the «blurring» of the boundaries between the digital and physical worlds, which opens up new possibilities for providing services to consumers just-in-time.

The level of distribution of new business models in Russia varies significantly by industry: the most common are digital platforms in markets characterized by close interaction between suppliers and consumers, in retail, financial services, consumer goods and services, where platform solutions have been actively developing since the beginning of 2010-th years. By 2035, it is planned launch Russian «smart» factories of the future. The largest enterprises actively apply standardized solutions related to predictive maintenance and repair, automated quality control systems, real-time remote monitoring and energy management systems. However, technological solutions that contribute to changing the business model of enterprises from product oriented to service have the greatest potential for creating added value.

In engineering in recent years, the level of ICT costs (relative to output) is about 8%, which is comparable to the transport costs of the sector. In general, the intensity of costs for ICT products in Russia is slightly behind the US level (2.46% versus 3.08%). To a large extent, the lag of individual segments of the Russian economy in terms of digitalization is associated with low volumes of investments in digital infrastructure (software, electronic component base, etc.), which in Russia (1.46% of GDP) are much lower than the American level (2.8% Of GDP). Under the conditions of sanctions, more expensive imported technologies are slowly being replaced by domestic ones, which hinders the pace of modernization of digital infrastructure.

## 5. Conclusions

In a nutshell, the chief purpose of the study was to analyze several features of the digital economy and stages of the formation of this concept. Hence, the F-Limer and Hausman statistic tests were employed to gather the estimation method on the basis of panel data or the combined data method. Based on the results obtained, it can be concluded that the most difficult and multifaceted task is to stimulate mass demand for digital solutions from both business and the public. Without its solution, it is problematic to achieve the key target for the accelerated implementation of digital technologies, established by Decree No. 204, namely, «increasing the internal costs of developing the digital economy from all sources (in terms of GDP share) by at least 3 times» by 2024 by compared with 2017. The analyzes showed that the innovation index has significant effects on the competitiveness index and the growth of the innovation index has largely led to the growth of the competitiveness index.

Given the high role of state-owned companies in the Russian economy and industries that consume digital technologies (energy, transport, engineering), it is necessary to ensure their high-quality development of digital transformation strategies and the setting of KPIs for «digitalization». Along with this, it is advisable to pay attention to the development of a network of regional centers of competence, testing and supporting the replication of ready-made digital solutions, including for small and medium-sized businesses.

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