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Digital modernization of Kazakhstan's economy in the context of global trends

Abstract. An academic interest in the topic of digital economy is caused by the ever increasing digital technology possibilities as a new production factor. In digital production, added value is obtained as a result of information procession using digital technology, the final products of which are new products and services. Digital economy contributes to the rethinking of existing economic relations and formation of new pure digital economy sectors as the basis for a new information economy.

In this paper, we analyze theoretical aspects of the evolution of the «digital economy» concept; examine various scientific and expert opinions and views on current issues. The authors' approach to the definition of «digital economy» concept follows from the economic theory of «productive forces and production relations,» and is based on the premise of «new production relations».

This paper critically rethinks the state of digitalization in Kazakhstan, the implementation of the Digital Kazakhstan Program, which really showed the impact of the 2019-2020 coronavirus pandemic on digitalization, especially within healthcare, education, and public administration.

The results of the study suggest that at present, digital knowledge and digital literacy skills are becoming an urgent need for most citizens to improve their efficiency of work and the employee qualification. A comparative analysis of the digital economy's development level across leading and developing countries has shown a number of significant factors that hinder digitalization in Kazakhstan, such as the lack of a full-fledged digital infrastructure (IT capacity, limited technological capabilities, etc.).

As a result of the study, we have determined a lag in both implementation of digital communication technologies and development of digital business in Kazakhstan. Simulation results show that the effective digital economy development in Kazakhstan requires ensuring a positive dynamics of such key digital growth indicators, as the availability of digital communication technologies and the volumes of digital business, which have a positive correlation with the development of digital literacy, and the level of e-government.

Mathematical methods we used in writing this paper have allowed us to develop a predictive model of the digital economy development in Kazakhstan in the medium term. We have made specific conclusions and recommendations for the development of the digital economy in Kazakhstan for the near future.

Keywords: Digitalization; Digital Economy; Digital Technologies; Indices; Projection; Information and Communication Technologies; Kazakhstan

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Цифрова модернізація економіки Казахстану в контексті світових трендів

Анотація

Науковий інтерес до тематики цифрової економіки обумовлений зростаючими можливостями цифрових технологій як нового фактора виробництва. У цифровому виробництві додана створюється в результаті обробки інформації з використанням цифрових технологій. Цифрова економіка сприяє переосмисленню сформованих економічних відносин, а також формуванню нових чистих цифрових галузей економіки як основи нової інформаційної економіки.

У статті подано аналіз теоретичних аспектів еволюції поняття «цифрова економіка», вивчено думки, погляди вчених, експертів на актуальну проблематику. Авторський підхід до визначення поняття «цифрова економіка» впливає з економічної теорії про продуктивні сили та виробничі відносини й ґрунтується на постулаті «нових виробничих відносин».

У статті критично переосмислено стан цифровізації в Казахстані та хід виконання програми «Цифровий Казахстан», що реально показав вплив пандемії коронавірусу 2019–2020 років на процес цифровізації, особливо в сферах охорони здоров'я, освіти, державного управління.

Результати дослідження показують, що в даний час цифрові знання й навички цифрової грамотності стають нагальною потребою для більшості громадян країни для підвищення ефективності праці та кваліфікації працівника. Порівняльний аналіз рівня розвитку цифрової економіки провідних країн та країн, що розвиваються, показав ряд істотних факторів, які гальмують цифровізацію в Казахстані, зокрема відсутність повноцінної цифрової інфраструктури (слабкість ІТ-потужностей, технологічних можливостей та ін.).

У результаті дослідження виявлено відставання щодо впровадження цифрових і комунікаційних технологій і розвитку цифрового бізнесу в Казахстані. Результати проведеного моделювання показують, що для ефективного розвитку цифрової економіки Казахстану необхідно забезпечити зростання таких ключових індикаторів цифрового зростання, як забезпеченість цифрових і комунікаційних технологій і обсяги цифрового бізнесу, які мають позитивний взаємозв'язок із розвитком цифрової грамотності населення, рівнем електронного урядування країни.

Використання математичних методів при написанні статті дозволило розробити прогнозну модель розвитку цифрової економіки Казахстану на середньострокову перспективу. Авторами зроблено конкретні висновки й надано рекомендації щодо розвитку цифрової економіки Казахстану на найближче майбутнє.

Ключові слова: цифровізація; цифрова економіка; цифрові технології; індекси; прогнозування; інформаційно-комунікаційні технології; Казахстан.

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Цифровая модернизация экономики Казахстана в контексте мировых трендов**Аннотация**

Научный интерес к тематике цифровой экономики обусловлен возрастающими возможностями цифровых технологий как нового фактора производства. В цифровом производстве добавленная стоимость создается в результате обработки информации с использованием цифровых технологий. Цифровая экономика способствует переосмыслению сложившихся экономических отношений, формированию новых чистых цифровых отраслей экономики как основы новой информационной экономики.

В статье дан анализ теоретических аспектов эволюции понятия «цифровая экономика», изучены мнения, взгляды ученых, экспертов на актуальную проблематику. Авторский подход к определению понятия «цифровая экономика» вытекает из экономической теории про производительные силы и производственные отношения и основывается на постулате «новых производственных отношений». В статье критически переосмыслены состояние цифровизации в Казахстане и ход выполнения программы «Цифровой Казахстан» с учетом влияния пандемии коронавируса 2019–2020 годов на процесс цифровизации, в особенности в здравоохранении, образовании, государственном управлении.

Результаты исследования показывают, что в настоящее время цифровые знания и навыки цифровой грамотности становятся насущной потребностью для большинства граждан страны, а также для повышения эффективности труда и квалификации работников. Сравнительный анализ уровня развития цифровой экономики ведущих и развивающихся стран показал ряд существенных факторов, тормозящих цифровизацию в Казахстане, в частности отсутствие полноценной цифровой инфраструктуры (слабость IT-мощностей, технологических возможностей и др.).

В результате исследования выявлено отставание по внедрению цифровых и коммуникационных технологий и развитию цифрового бизнеса в Казахстане. Результаты проведенного моделирования показывают, что для эффективного развития цифровой экономики Казахстана необходимо обеспечить рост таких ключевых индикаторов цифрового роста, как обеспеченность цифровых и коммуникационных технологий и объемы цифрового бизнеса, которые имеют положительную взаимосвязь с развитием цифровой грамотности населения и уровнем электронного правительства в стране.

Использование математических методов при написании статьи позволило разработать прогнозную модель развития цифровой экономики Казахстана в среднесрочной перспективе. В заключение сделаны конкретные выводы и рекомендации относительно развития цифровой экономики Казахстана на ближайшее будущее.

Ключевые слова: цифровизация; цифровая экономика; цифровые технологии; индексы; прогнозирование; информационно-коммуникационные технологии; Казахстан.

1. Introduction

The global economic space is facing a steady trend of digitalization development being formed as an objective element of new industrial relations. In the digital economy, digital technologies get the final product based on the results of information processing. There is a change in productive relations at a higher level of increasing labor productivity, the emergence of new purely digital industries.

Digital technologies cause fundamental changes in economic relations, increase the level of competitive opportunities of national economic sectors and the formation of a «digital society.» Digital economy, as a new type of management based on information processing for management in all cycles of production and consumption, will serve as the basis for the development of future economy as a whole. Transformation of the accelerated transition of the national economy to new digital technological solutions will raise it to a qualitative level of development, for Kazakhstan's

reality in a departure from the one-sided raw material model. All this confirms the relevance of the study of the digital economy development issues.

Methodological basis of the study. In the course of the study, we used a set of methods, such as observation, generalization, comparison, analysis, systematization, processing, economic and mathematical modeling.

2. Brief Literature Review

Conceptual foundations of the digital economy are laid in the scientific papers by such scientists as Nicholas Negroponte (1995), who believed the information volume of a digital nature to be the basis of the new digital economy; Don Tapscott (1996) who was the first to propose a definition of the digital economy in his book «Digital Economy: Promise and Peril in the Age of Networked Intelligence:» an economy based on the use of information computer technologies and many others.

In the time following, with the progress of scientific thought, and the emergence of new technologies, research of trends in the transformation of the world economy to a digital one conducted by many scientists, experts, international organizations has enjoyed a rapid development. This included Brynjolfsson, Kahin (2000), Mesenbourg (2001), Johansson, Karlsson, Stough (2006), Skilton (2015), Doucek, Fischer, Novotny (2017), Glazyev (2017), Shvab (2016), Gokhberg (2019), Golovenchik (2019), Zhang, Chen (2019), Bukht, Heeks (2018), Ozili (2018), Kulkov (2017), Dobrynin et al. (2016) and many others who in their scientific research consider various theoretical aspects, features of the evolutionary development of the digital economy, the use of digital technologies, and the impact of digitalization on economic growth. We have summarized their main conclusions:

- 1) Objectivity of the transition to new economic relations (the sixth technological order associated with the information revolution (Glazyev, 2017), K. Shvab: «Changes in the nature of production or economic relations...» (Shvab, 2016).
- 2) Digital economy, as a number of economic and social activities carried out by internet users using digital technologies.
- 3) Digital economy is the production using digital technologies in production and trade of goods and services (Bukht, Heeks, 2018; Zhang, Chen, 2019; Dobrynin et al., 2016).
- 4) Digital economy is the main source of economic growth, and will stimulate competition, investment and innovation (Golovenchik, 2019; Gokhberg, 2019; Sembekov et al., 2020).

As practice shows, the structure of the modern digital economy includes production related to the use of digital technologies, such as ICT (telecommunications, internet, IT services, software production, network products, electronic trade of goods and digital services (telemedicine, distance learning, sales of goods, movies, books, television), and part of the branches of the «traditional» economy, in which digital technologies are introduced as necessary for production.

A whole number of scientific works identifies or compares the concept of «digital economy» with such economic categories as «information economy,» «knowledge economy,» «internet economy,» «net-economy,» «e-economy,» «new economy,» etc. In this case, we endorse the statement by Sembekov et al. (2020) that the above terms are used as certain synonyms to denote new changes in the economy as technological development and the formation of more modern productive digital technologies, the internet, and neural digital networks.

Some authors have made an attempt to combine all these terms into one direction, calling it the new economy. This broad definition covers network business and e-commerce (business using ICT), online operations, etc. Digital economy also includes an algorithmic economy based on the processing of Big Data, and platform companies (Amazon, eBay and Alibaba, Uber, Airbnb) (Huckle et al., 2016).

Digital economy is enjoying the emergence of new industries, such as the digitized economy, the economy of free earnings, the algorithmic economy, the logistics economy. All of these are a part of the digital economy space.

Consequently, the objectivity of the emergence of new digital economy branches causes the use of the following new terms of the digital economy in research: «digital finance,» «digital currency,» «digital assets,» «digital operations,» «cryptocurrency exchange,» «digital financing,» «financial integration», etc. (Ozili, 2018).

Digital economy acts as an economic production with modified production relations, in which digital technologies are the main factors of the digital economy (Figure 1).

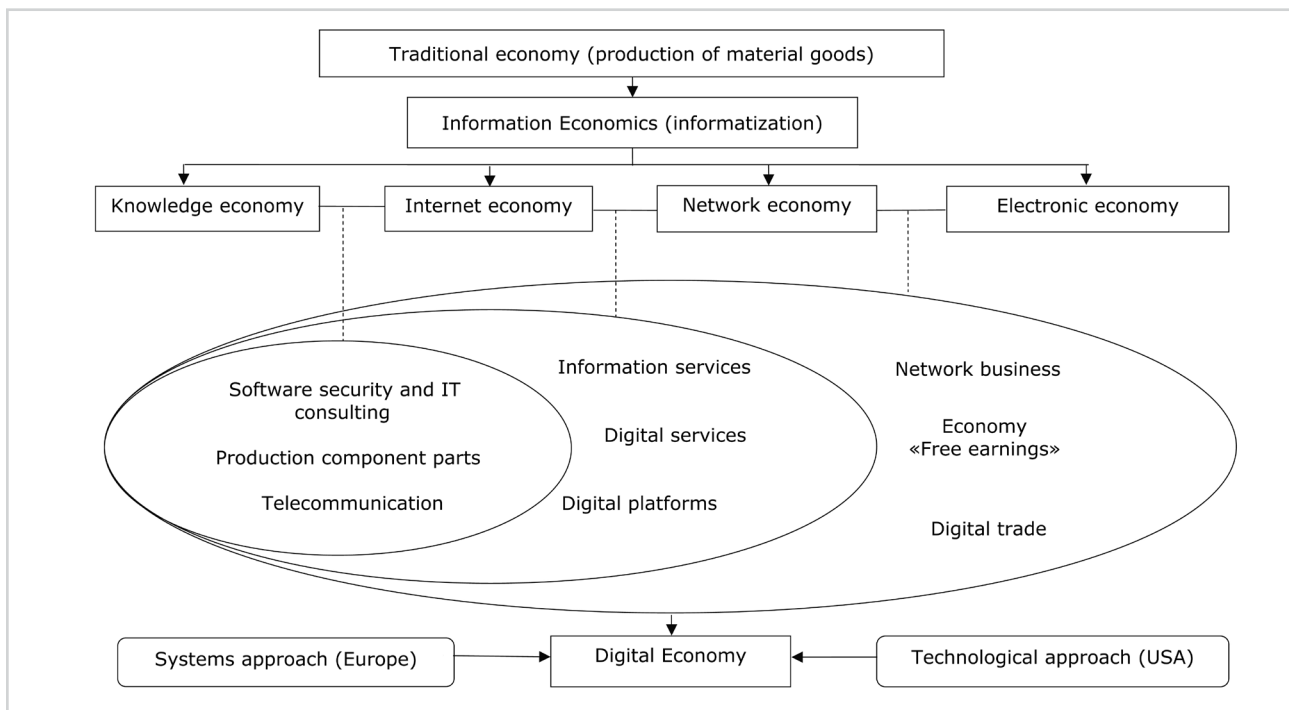


Figure 1:
Economy evolution

Source: Developed by the authors using sources
(Zhang, Chen, 2019; Bukht, Heeks, 2018; Dobrynin et al., 2016)

Thus, the authors base their reasoning for the «digital economy» concept definition on the economic theory of «the system of productive forces (knowledge, technology and tools) - production (economic) relations.» At the core of the traditional economy, real labor would create surplus value. At one time, such means of production as the loom or electricity would provide a higher labor productivity. With the introduction of digital technologies in the production process more productive means of labor came as well.

We believe that the digital economy is a system of new production (economic) relations through the use of digital technologies, in which value added is based on the results of information procession (Sembekov et al., 2020).

To date, proven methods for assessing the criteria for the digital economy development are non-existent. An analytical review of the scientific works by both foreign and local scientists allows us to draw attention to the following features and contradictions that characterize the development of the digital economy in the world:

1. Digital economy based on modern technological solutions is most strongly developed in the leading countries (USA, South Korea, Japan, Great Britain, China), which have a powerful scientific and technological potential, highly qualified experts, respectively, and world class high-tech companies. According to the data found in Mary Meeker's report 2018 Internet Trends, all the largest technology companies by capitalization are concentrated in the United States and China, and their combined capitalization is approximately USD 5.9 trillion, with 75% of the value coming from US companies and 25% from Chinese ones. These are Apple, Alphabet, Facebook (two-thirds of the global social media market), Amazon (almost 40% of global online retail sales), Microsoft, Google (about 90% of the search engine market), eBay, Tencent, Alibaba, etc. (BCS Express, 2018).

2. Digital economy is poorly represented in developing countries due to the above-mentioned reasons. Currently, there is a huge gap in the world between countries with poor internet development and highly digitalized countries. For example, in the least developed countries, only one in five people have access to the web, while in developed countries, it is four out of every five people (United Nations Conference on Trade and Development, 2019).

Developing countries' desire to accelerate the digital economy development is possible in countries with great technological potential for national development: India, Brazil, Russia, etc., to accelerate economic growth faster than in traditional sectors of the economy.

3. The change in production relations of the traditional economy, the emergence of new digital factors of production of the digital economy contributes to the emergence of new organizational forms, new specialties, the demise of many types of activities and professions of the traditional economy. Employees with a good level of knowledge in digital technologies will find themselves in a better position, will be more competitive. Local companies in the traditional economy will not be able to withstand the fierce competition from domestic and foreign companies using digital technologies, and various activities will simply disappear as a result of automation and reformatting of qualification requirements for employment, which is quite clear in the context of the 2019-2020 coronavirus epidemic.

4. Strengthening of social, economic, technological and other contradictions in the conditions of digitalization: a discrepancy between the employee interests and digital technology, demise of some occupations, emergence of new ones requiring high computer literacy, a potential increase in unemployment, violation of personal life, confidentiality of personal data, cybersecurity issues at the national, macroeconomic (industry) and microeconomic (enterprises, private business) levels.

5. Digital technologies will be used in the most prepared sectors of the economy. World experience shows that the most prepared for the introduction of digitalization are financial markets (banks, insurance companies, pension funds), telecommunications, network and logistics companies, as a supplement in education, urban infrastructure (video systems, smart apartments and houses, etc.).

3. The purpose of the study is to analyze the current state of digital economy in Kazakhstan, and to identify existing issues in its development. Conducting an economic and mathematical projection of digital indices of the national economy in the medium term, development of proposals for improving digital growth.

4. Results

The analysis of current state of world digitalization shows that introduction of digital communication technologies (ICT) in economic, social and public relations will allow the state and society to advance to a higher level of development. Currently, the issues of economy digitalization are the main priority for a multitude of countries aiming to achieve high level of economic growth.

Leading countries of the world have the necessary scientific, technical and technological potential for the digital economy development, conducting research to create new technological solutions, unlike Kazakhstan as a developing economy with limited financial and technical capabilities. Leading high technology countries (UK, USA, Singapore, Republic of Korea, Japan, Denmark, and China) note that qualitative development of the digital sector was preceded by the presence of fundamental basics of scientific and technical potential, which formed the national programme for the digital economy development. For example, the US and China account for 75% of all patents related to blockchain technologies, 50% of global spending on the Internet of Things, and more than 75% of the global market for open cloud computing technologies. Digital economy is estimated to account for between 4.5 and 15.5% of global GDP. Almost 40% of the value added generated in the global information and communication technology (ICT) comes from the United States and China (United Nations Conference on Trade and Development, 2019).

According to the World Bank, analysts project a significant increase of the digital economy's share in total GDP: by 2035, its volume will exceed USD 16 trillion (Digital McKinsey, 2017). Today, e-commerce is growing by up to 25% annually in developing countries, while no other sector of the economy can get any near such rates (Government of the Republic of Kazakhstan, 2017).

According to the number of studies of the digitalization level, the economy of Kazakhstan is in its initial stage of development of the digital economy. Kazakhstan, due to its potential, has identified priorities for the national development of digitalization. The adopted state program «Digital Kazakhstan» notes the creation of the digital economy of the future in the long term in two development vectors. First, «Digitalization of the existing economy,» consists of specific projects in the real sector, projects on digitalization and technological re-equipment of existing economy sectors and state structures. The next stage, «Creating the digital industry of the future» is to ensure the country's digital transformation by increasing the level of human capital development, building institutions for innovative development and, in general, creating a digital ecosystem.

The Digital Kazakhstan program plans to implement about 140 projects, of which 44 projects will be implemented by the public sector, and 69 projects will be financed from the state budget (Government of the Republic of Kazakhstan, 2017).

This Program has adopted the following five main directions:

1. «Digitalization of economic sectors»;
2. «Transition to a digital state»: transformation of the state's functions to create a digital infrastructure;
3. «Implementation of the Digital Silk Road»: development of high-speed and secure infrastructure for data transmission, storage and processing;
4. «Human capital development»: transformation to ensure the transition to new realities, the knowledge economy;
5. «Creating an innovative ecosystem»: creating conditions for the development of technological entrepreneurship and innovation (Government of the Republic of Kazakhstan, 2017).

Thus, the adopted state program «Digital Kazakhstan» shows that the issue of digitalization of the Kazakhstan economy remains relevant, and, accordingly, state has developed policy measures to create foundations of the digital economy as a new branch of the economy of the future.

A comparative analysis of Kazakhstan's digitalization indices with other countries, calculated on the basis of four indices (digital literacy of the population, ICT, digital business, digital state services) shows that Kazakhstan is among those lagging behind along with Egypt, India and Asia-Pacific countries (We Are Social and Hootsuite, 2017).

According to media reports, Kazakhstan has achieved certain positive results in digitalization in a short period of time. In December 2019, the Prime Minister of Kazakhstan A. Mamin at the plenary session of the conference «Digital Samruk» dedicated to digitalization of the Kazakhstan economy, has noted the success in digitalization of the Kazakh economy for further growth. According to A. Mamin, «The total economic effect of the Digital Kazakhstan Program for 2018 and 2019 has exceeded 1.568 billion US Dollars (average national currency exchange rates against US Dollar for 2019 is 382.75 tenge). Significant progress has been made in the introduction of digital technologies in public services, education, healthcare, financial, transport and mining and metallurgical sectors, which allowed Kazakhstan to improve its position in the current world rankings» (Prime Minister of the Republic of Kazakhstan Mamin, A.U., 2019; National Bank of the Republic of Kazakhstan, 2020).

For example, in healthcare, the following digital solutions have accelerated: development of services for electronic medical records, tracking patients and their health parameters, use of artificial intelligence for quick and accurate diagnostics, online health indicator review, teleconsultations, etc. At the same time, the coronavirus epidemic, which required the active use of digital services in education, healthcare, and public administration, has revealed systemic shortcomings in the implementation of digitalization in the country.

Thus, the analysis of the state program «Digital Kazakhstan» and the actual results of the use of digital technologies in the conditions of COVID-2019 quarantine shows a number of systemic shortcomings:

1. Development of the state budget for the «Digital Kazakhstan» program has not considered the pressing issues of digital provision of the population and society with services, which was manifested in the COVID-2019 quarantine conditions. The allocated funds of 368.4 million US Dollars for the implementation of 17 targets were insufficient to fully cover all sectors of the economy.
2. As the practice of forced transfer of many services to the population online in the context of the coronavirus epidemic of 2019 has shown, many digital services could not fully meet the needs of people due to software failures, poor connection, unpreparedness of servers for the large volumes of requests, lack of digital services, etc.
3. It should be noted that digital platforms have not been properly developed in the country. There is a lack of ICT security, poor development of digital business and limited digital services. Formation of a flexible digital infrastructure remains the first priority for the state and citizens.
4. The state program does not reflect the issues of safety, protection and confidentiality of personal data in databases; the interaction of state databases, the issues of their modernization into a single whole for the citizen-consumer becomes relevant.
5. The sad 2019 experience of forced transfer to digital platforms of many types of economic activity has shown that while allocating large financial resources to the health and education sectors,

the state has failed to ensure the quality of digitalization in these industries. And what can we say about private business, which would have to survive in quarantine with limited resources? They would solve a feasible task to save the business with minimal losses. Private companies will resort to digitalization only when it is economically profitable for them.

Implementation of the state policy for the digital economy development is impossible without a deep analysis and modeling of the development of complex indices that characterize the use of digital technologies in the public sector, business and by citizens. The level of digital development in Kazakhstan should be characterized on the basis of the analysis of the following aggregative indices:

- 1) digitalization of the public sector,
- 2) digital literacy of the population,
- 3) development and volume of digital business, and
- 4) provision of ICT.

The level of digital development of the public sector in developing countries is characterized by the quantity and quality of public services provided by the state in various sectors, primarily budgetary areas, such as education and health. Although Kazakhstan took the 28th place in the UN e-Government Development Index (EGDI) for 2019 (39 for 2018), the 2020 practice, as a result of the mass forced use of digital platforms and technologies, has shown weakness and conditionality of the index assessment. The E-Government Development Index should reflect the state of development of e-government of the state, characterize access to digital infrastructure, the level of educational potential of the country in terms of the possibilities of using digital technologies, their development and implementation.

Digital (computer) literacy of the population. The results of various studies show that currently, digital knowledge and skills are becoming an urgent need for most citizens of the country; they are required for obtaining a working specialty in a digital format in order to be competitive. Citizens do understand the need for digital transformation, and mastering digital and computer knowledge.

Development of digital business and ICT. The ICT market is the basis for the successful development of the digital economy in any country. The largest component of the ICT sector is computer services, which account for 40% of all value added generated in the sector. The global computer services industry is dominated by the United States, which accounts for almost as much of the value added generated by the industry as the next nine major economic powers combined (United Nations Conference on Trade and Development, 2019).

According to Forrester Research, in the global IT market, consulting and various integration services account for 19%, 23.3% for hardware, and 21% for software (the rest is telecommunication services and equipment, etc.) (Forrester Research, 2019).

To assess the level of digitalization in the country, we have systematized an overview of the dynamics of volumes in ICT, an analysis of the EGDI e-government development, the number of IT companies by year, E-Gov (services rendered) and the level of computer literacy. We have summarized the data obtained in Table 1.

According to the analysis, the ICT market in Kazakhstan is developing both one-sidedly and poorly. Digital services, production of digital products and software are poorly developed in the country. At the same time, it should be noted that the volume of services and production of ICT, the number of IT companies expand from year to year, which is a positive trend. The level of computer and digital literacy is increasing, and the availability of such competencies is becoming an urgent need. Technical and hardware support is dominating on ICT market, it accounts for most of

Table 1:
Quantitative indicators of digitalization in the Republic of Kazakhstan (2013-2019)

Indicators	Years							
	2013	2014	2015	2016	2017	2018	2019	
Population's computer literacy level, %	61.25	64.1	74.2	76.2	78.2	79.6	82.35	
E-Government Development Index (EGDI)	37	28	31	33	32	39	28	
E-Gov (services rendered), thousand	24000	34500	24500	26000	34000	27500	23500	
Volume of ICT services, million US Dollars	5083.2	4634.7	3981.9	2760.1	3174.4	3245.7	3514.7	
Number of IT companies	1075	11668	14849	15720	15288	13295	16863	
IC production volume, billion US Dollars	12.6	8.7	7.2	4.8	5.7	6.2	6.3	

Source: Compiled by the authors based on the sources (JSC «National Information and Communication Holding» Zerde», 2019; United Nations Public Administration Network (UNPAN), 2020; International Data Corporation, 2019; National Bank of the Republic of Kazakhstan, 2020)

the market (78.7%) according to the report «Development of the ICT Industry in the Republic of Kazakhstan by the End of 2019» by the «Zerde» National Infocommunication Holding» JSC.

Now, let us project the index indicators of the digital economy development (for calculation, we chose the index-numerical literacy of the population) in Kazakhstan in the medium term until 2022, using mathematical methods. To calculate dynamics indicators of the indicator development on a constant basis, we compare each level of the series with the same basic level. Indicators calculated this way are basic. To calculate dynamics indicators on a variable basis, we compare each subsequent level of the series with the previous one. Dynamics indicators calculated this way are chained. To calculate the dynamics indicators on a variable basis, we compare each subsequent level of the series with the previous one. We also assess the dependence of indicators using Spearman's rank correlation method.

Regarding the literacy rate indicator, calculation of chain indicators of a series is presented in Table 2. All other key indicators are calculated the same way.

In 2019, compared to 2018, literacy rate increased by 2.75, or 3.5%. The maximum increase (of 10.1) is in 2015. The minimum increase (of 1.4) was in 2018. The rate of increase shows that the trend of the series is growing, which indicates an acceleration in the increase in the literacy level. Table 3 shows the basic indicators of the literacy level time series.

In 2019, compared to 2013, literacy rate increased by 21.1, or 34.5%. Calculation of the average characteristics of the series. The average level of the y-series characterizes the typical value of absolute levels.

The average level of an interval series is calculated using the following formula:

$$\bar{y} = \frac{\sum y_i}{n}, \quad (1)$$

$$\bar{y} = \frac{515.9}{7} = 73.7.$$

The average literacy rate from 2013 to 2019 was 73.7.

Average growth rate:

$$\bar{T}_p = \sqrt[n-1]{\frac{y_n}{y_1}}, \quad (2)$$

$$\bar{T}_p = \sqrt[6]{\frac{82.35}{61.25}} = 1.0506.$$

The average growth of the analyzed indicator for the entire period was 1.0506.

Average increase rate:

$$\bar{T}_{np} = \bar{T}_p - 1, \quad (3)$$

$$\bar{T}_{np} = 1.0506 - 1 = 0.0506.$$

Table 2:
Chain indicators of a series

Period	Literacy rate	Absolute growth	Increase rate, %	Growth rate, %	Absolute content of a 1% increase	Build-up rate, %
2013	61.25	-	-	100	-	0
2014	64.1	2.85	4.65	104.65	0.6125	4.65
2015	74.2	10.1	15.76	115.76	0.641	16.49
2016	76.2	2	2.7	102.7	0.742	3.27
2017	78.2	2	2.62	102.62	0.762	3.27
2018	79.6	1.4	1.79	101.79	0.782	2.29
2019	82.35	2.75	3.45	103.45	0.796	4.49

Source: Compiled by the authors

Table 3:
Basic indicators of a series

Period	Literacy rate	Absolute growth	Increase rate, %	Growth rate, %
2013	61.25	-	-	100
2014	64.1	2.85	4.65	104.65
2015	74.2	12.95	21.14	121.14
2016	76.2	14.95	24.41	124.41
2017	78.2	16.95	27.67	127.67
2018	79.6	18.35	29.96	129.96
2019	82.35	21.1	34.45	134.45

Source: Compiled by the authors

On average, literacy rate would increase by 5.1% annually. The average absolute increase is a generalized characteristic of individual absolute increases in a series.

The average absolute increase:

$$\overline{dy} = \frac{y_n - y_1}{n - 1}$$

$$\overline{dy} = \frac{82.35 - 61.25}{6} = 3.52.$$
(4)

Every year, literacy rate would increase by an average of 3.52.

Let us project for three steps forward, using the average growth rate indicator:

$$y(2020) = 82.35 \cdot 1.0506 = 85.87,$$

$$y(2021) = 85.87 \cdot 1.0506 = 89.39,$$

$$y(2022) = 89.39 \cdot 1.0506 = 92.91.$$

Using this methodology, we have built a model for forecasting the development of key indicators of the digital economy of Kazakhstan (Figure 2).

Projection shows the greatest growth in digital literacy, positive trends in ICT and EGDI development, which create opportunities for the development of human capital and the formation of a Kazakh society with the necessary digital competencies.

The study included an analysis of a representative survey of the population (according to international organizations) and an empirical statistical study of the information society development factors (including an analysis of indicators of ICT use in the Republic of Kazakhstan), as well as the results of recent studies on the role of ICT in economic development.

For a more accurate estimate, we used the exponential smoothing method. In it, the projection estimate is more in line with the trends of recent years, which is its main advantage.

We used this method for short-term projection. It is based on the use of weighted average values of the studied indicators for a certain number of past periods. At the same time, the largest weight coefficients are given to the latest data. In addition, we used the method of leading indicators. These were values and their time series, which change in the same direction as the studied indicator, but are ahead of it in time. Also, in the course of the study, we used a multivariate dispersion analysis to build a prediction estimate of the digital economy development in the medium term until 2022.

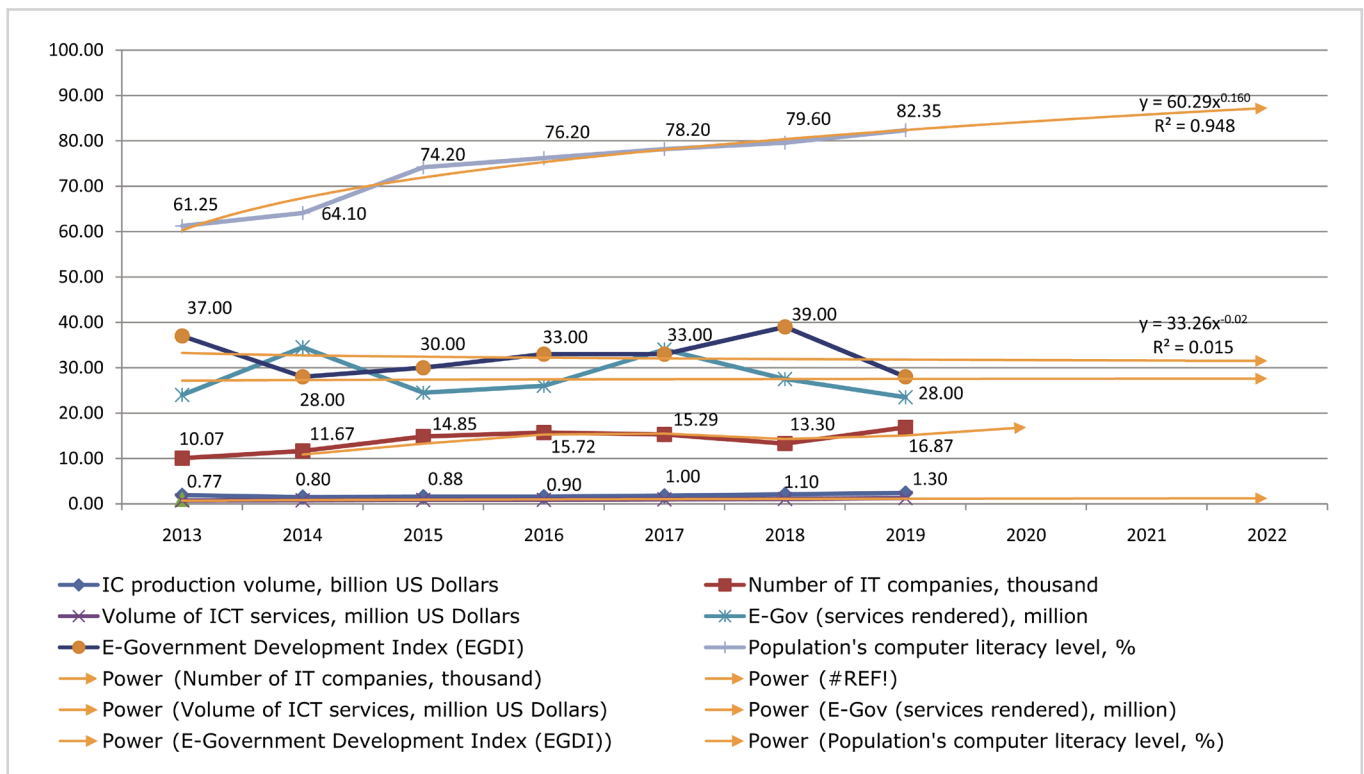


Figure 2:
Projection of the digital economy indicator development in Kazakhstan
Source: Compiled by authors

Since almost all indicators of the digital economy of Kazakhstan have $Tkp < \rho$, we reject the hypothesis that Spearman's rank correlation coefficient is equal to 0. In other words, rank correlation coefficient is statistically significant and the rank correlation between the scores on the tests performed is significant as well.

Thus, the main index with the highest correlation ratio between coefficient rank correlation and other indicators, like other correlation coefficients, assessed on a Chaddock scale are an indicator of the computer literacy level, as well as in the first approximation to it, the indices of the provision of ICT and IT companies, which is reflected in Figure 3.

5. Conclusions

1. The study has confirmed that the effective digital economy development in Kazakhstan requires an increase in the availability of ICT and digital business, which have a direct relationship with the development of digital (computer) literacy and the EGDl development level.
2. Using economic and mathematical methods of these digitalization indices, we have empirically confirmed the positive relationship between the development of e-government and digital economy.
3. The current Program «Digital Kazakhstan» needs to be adjusted taking into account the identified shortcomings and issues in the context of the coronavirus pandemic in 2020, simplified approaches to the digitalization program to be avoided. The pandemic has clearly revealed the lack of a full-fledged digital infrastructure (IT capacity, servers, online capabilities, etc.), which shows its need to be built for the development of digitalization.
4. Kazakhstan' education system should take into account current changes in the economic policy of national development. Extremely important is training of IT specialists, which requires the state policy in both higher and secondary education, to take into account the employer needs, to organize coordination between enterprises and universities in training IT experts, to develop an effective model of cooperation in R&D between universities and employers.

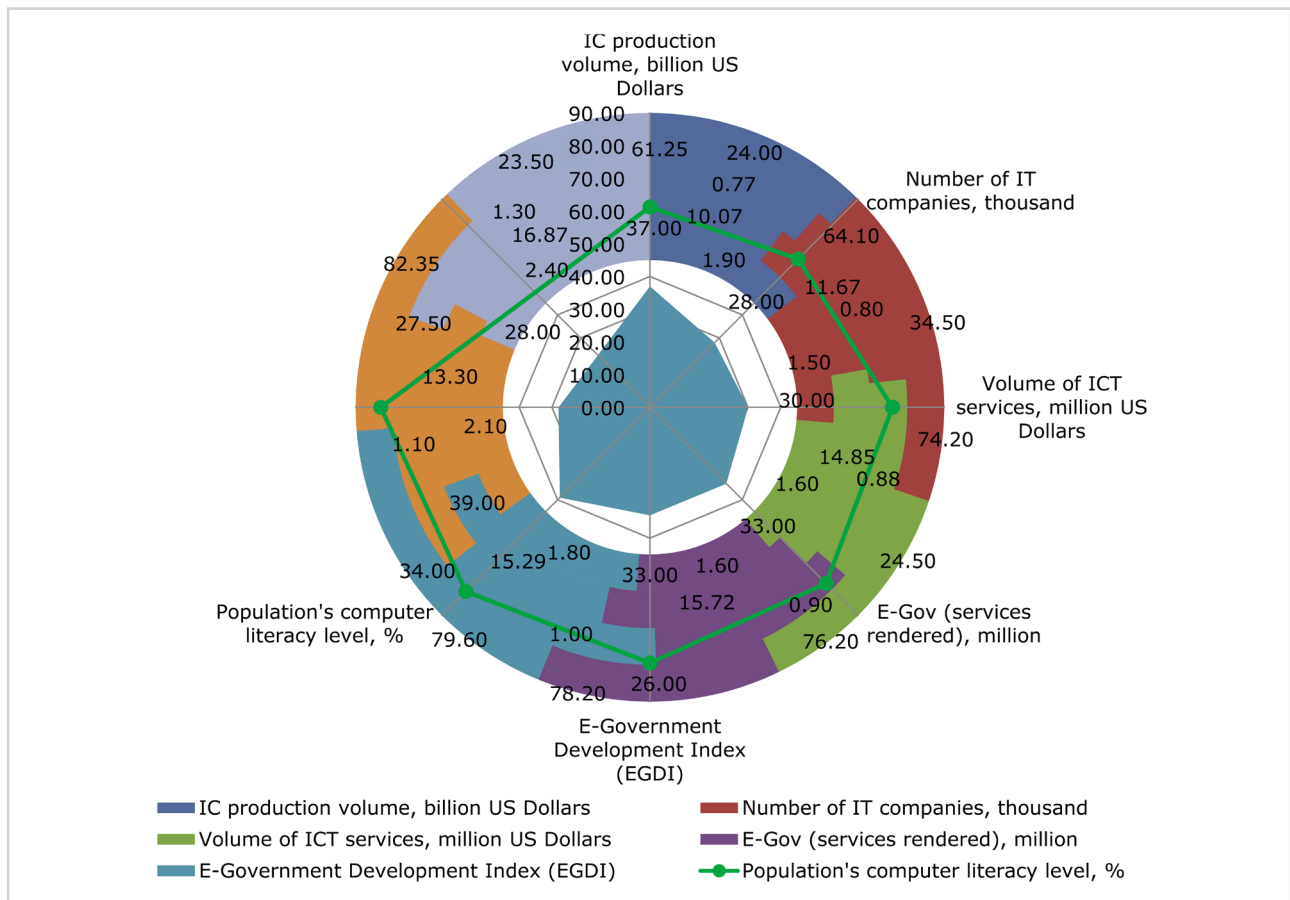


Figure 3:

Predictive relationship of the main indicators of the digital economy development in Kazakhstan

Source: Compiled by authors

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