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The Impact of Digitalization on Socio-Economic Development of the Metropolis (on the Example of Almaty)

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ABSTRACT

The purpose of this article is to explore the impact of digitalization in megacities on its socio-economic indicators using the example of Almaty city since it is one of the cities that meets the requirements of a megacity. Digitalization today is one of the factors in the development of both the economy and other areas. Digital transformation taking place in the world affects important industries and areas of all territories, but this is especially true for large cities. Since it ensures the vital activity of these cities, facilitating the life of the population and management processes. In this study, the index of digitalization of the metropolitan economy was calculated, which consists of three sub-indices. Further, a correlation-regression analysis was carried out between digitalization indicators and socio-economic indicators: average monthly salary, gross regional product (GRP), population and life expectancy. Four hypotheses were put forward, of which three were accepted, and one rejected. Economy digitalization has a significant impact on average monthly salary, GRP and population increase. Excel and SPSS programs were used for calculations. Data from the National Bureau of Statistics of the Republic of Kazakhstan from 2016 to 2021 was used. The results showed a positively strong and high correlation between digitalization and population size, average monthly salary and GRP. And a high negative correlation between life expectancy. The study's results can be used in the development of megacities, where digitalization programs are being implemented to improve the results of the introduction of digital technologies in the socio-economic sphere.

KEYWORDS: Economy, Megacities, Digitalization, Socioeconomic indicators, GRP, Business Organizations, Economics of Urban Areas

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Цифрландырудың мегаполистің әлеуметтік-экономикалық көрсеткіштеріне әсері (Алматы мысалында)

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ТҮЙІН

Бұл мақаланың мақсаты мегаполистерді цифрландырудың оның әлеуметтік-экономикалық көрсеткіштеріне әсерін зерттеу болып табылады, Алматы қаласы мысалында, өйткені ол мегаполистің талаптарына сай келетін қалалардың бірі. Цифрландыру бүгінде экономиканың да, басқа да салалардың даму факторларының бірі болып табылады. Әлемде болып жатқан цифрлық трансформация барлық аумақтардың маңызды аймақтары мен салаларына әсер етеді, бірақ бұл әсіресе ірі қалаларға қатысты. Өйткені ол қалалардың тіршілігін қамтамасыз етеді, халықтың өмірі мен басқару процестерін жеңілдетеді. Бұл зерттеуде үш субиндекстен тұратын мегаполис экономикасын цифрландыру индексі есептелді. Одан кейін цифрландыру көрсеткіштері мен әлеуметтік-экономикалық көрсеткіштер: орташа айлық жалақы, жалпы өңірлік өнім (ЖӨӨ), халық саны мен өмір сүру ұзақтығы арасында корреляциялық-регрессиялық талдау жүргізілді. Төрт гипотеза ұсынылды, олардың үшеуі қабылданды және біреуі қабылданбады. Экономиканы цифрландыру орташа айлық жалақыға, ЖІӨ-ге және халықтың өсуіне айтарлықтай әсер етеді. Есептеулер үшін Excel және SPSS бағдарламалары қолданылды. Деректер 2016 жыл мен 2021 жыл аралығындағы Қазақстан Республикасы Ұлттық статистика бюросынан пайдаланылды. Нәтижелер цифрландыру мен халық саны, орташа айлық жалақы және ЖІӨ арасындағы оң күшті және жоғары корреляцияны көрсетті. Ал өмір сүру ұзақтығы арасында теріс жоғары корреляция бар. Зерттеу нәтижелері әлеуметтік-экономикалық салаға цифрлық технологияларды енгізу нәтижелерін жақсарту үшін, цифрландыру бағдарламалары іске асырылатын, мегаполистерді дамыту кезінде пайдаланылуы мүмкін.

ТҮЙІН СӨЗДЕР: экономика, мегаполистер, цифрландыру, әлеуметтік-экономикалық көрсеткіштер, ЖІӨ, кәсіпкерлік ұйымдар, қалалық аумақтардың экономикасы.

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Влияние цифровизации на социально-экономическое развитие мегаполиса (на примере Алматы)

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АННОТАЦИЯ

Целью данной статьи является исследование влияния цифровизации мегаполисов на его социально-экономические показатели на примере города Алматы, так как это один из городов, который соответствует требованиям мегаполиса. Цифровизация сегодня является одним из факторов развития как экономики, так и других сфер. Происходящая в мире цифровая трансформация затрагивает важные отрасли и сферы всех территорий, но особенно это касается крупных городов. Так как обеспечивает жизнедеятельность этих городов, облегчая жизнь населения и процессы управления. В данном исследовании был рассчитан индекс цифровизации экономики мегаполиса, который состоит из трех субиндексов. Далее был проведен корреляционно-регрессионный анализ между показателями цифровизации и социально-экономическими показателями: среднемесячной заработной платой, валовым региональным продуктом (ВРП), численностью населения и продолжительностью жизни. Было выдвинуто четыре гипотезы, три из которых были приняты и одна отвергнута. Цифровизация экономики оказывает значительное влияние на среднемесячную заработную плату, ВРП и прирост населения. Для расчетов использовались программы Excel и SPSS. Использовались данные Национального бюро статистики Республики Казахстан с 2016 по 2021 год. Результаты показали положительную сильную и высокую корреляцию между цифровизацией и численностью населения, среднемесячной заработной платой и ВРП. И отрицательная высокая корреляция между ожидаемой продолжительностью жизни. Результаты исследования могут быть использованы при развитии мегаполисов, где реализуются программы цифровизации для улучшения результатов внедрения цифровых технологий в социально-экономическую сферу.

КЛЮЧЕВЫЕ СЛОВА: экономика, мегаполисы, цифровизация, социально-экономические показатели, ВРП, бизнес-организации, экономика городских территорий

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Introduction

The digital transformation of cities is conditioned to information technology development in several areas. These areas include digital tools (big data, predictive analytics, cloud technologies, artificial intelligence), mobility, the “Internet of things”, technologies related to security functions and digital platforms. These technologies are crucial to the range of technological solutions for megacities’ infrastructure development (Alkhanov et al., 2022). In addition, digitalization is one of the main strategies for developing the urban economy, which is currently considered as a significant factor in economic growth. The increase in efficiency is achieved through the transition to a new technological level of the private sector, industrial development and establishment of new business entities in almost all sectors of the economy, as well as the introduction of innovative methods of interaction with partners in cities (Joshi et al., 2016; Litvinenko, 2020). Improving the efficiency of state and municipal strategy of the government is ensured by reducing barriers in the interaction of government, business and civil society. The transition to a new level of interaction of all subjects of the digital economy is ensured by the strategy of the implementation of the appropriate level of development of the information infrastructure. In this regard, the development of technologies and infrastructure of the digital economy are among the main tasks of state policy. Thus, in the Digital Kazakhstan Program, the development of information infrastructure, information security, and regulatory and staffing are among the basic directions for developing the digital economy. The need to develop information and telecommunications infrastructure and eliminate the “digital divide” of the subjects of the Republic of Kazakhstan is emphasized in various strategic documents of the country (Demenko & Savina, 2019).

At the same time, the effectiveness of digitalization must be assessed from the standpoint of its impact on socioeconomic dynamics. The scientific literature focuses on the essence of digitalization, its industry-specific aspects, as well as the factors and problems of the digital transformation of the economy. Thus, digitalization is an accelerating expansion of the Internet as a communication tool, mobile Internet, and commercial platforms that affect the functioning of businesses, public institutions and individuals (Milošević et al., 2018). The term “digitalization” is broader than the digital economy since intro-

ducing digital technologies occurs in all spheres of human activity, not just the economy. At the same time, digitalization is a particular manifestation of the broader phenomenon of informatization of society, i.e. Digitalization is a current stage in the development of informatization.

The work considers the digital economy’s communicative, infrastructural and sectoral aspects. Within the framework of the communicative approach, the issues of using information and computer technologies for economic and social interactions through the private sector and business development are considered. Ensuring effective communications between all subjects of the digital economy requires the availability of an appropriate infrastructure. In this regard, when defining the essence of the “digital economy” concept, several authors focus on its infrastructure, including technical means, centers for storing, processing and converting information, software, telecommunications, etc.

Wahba S., World Bank Global Director of Urban Practices, and Vapaavuori J., Mayor of the City of Helsinki, outlined their vision for a functional city and how it is coping with the coronavirus pandemic in a joint article. Moreover, urbanization will continue because of the crisis, and cities will continue to attract innovation and people, creativity and capital. Also, digitalization will offer solutions that will make the global community of cities even more interconnected (Rodríguez-Barcón, 2020).

When studying digitalization, it is essential to assess its effectiveness in improving the economic dynamics of the socioeconomic development of cities. The state pays great attention to developing information infrastructure in the regions, creating conditions for digitalizing public services and business development. In this regard, the issue of analyzing the impact of digitalization processes on the dynamics of the socioeconomic development of regions is relevant.

The megacities under consideration are of republican significance, with a population of more than one million. Therefore, it is essential to consider how digitalization affects the socioeconomic indicators of the city. This study will examine the relationship between the level of digitalization of business in the city of Almaty and the growth index of the GRP and socioeconomic indicators.

Literature review

Digitalization is currently the locomotive of economic growth and development, an innovative field that connects urban residents, consolidates the forces of economically active citizens and supports the dynamics of all urban processes. The digital transformation unfolding in the world affects vital industries and areas that, on the one hand, are concentrated in cities and, on the other hand, are integral parts of its life support: modern production, transport and mobility, energy, communications, housing and communal economy, trade and services, healthcare, education, municipal government systems. It is known that digital technologies provide the cheapest ways to solve many problems in logistics, management, and communications, allow regions to compensate for resource insufficiency, and increase the attractiveness of the living environment. The economic development strategy through digitalization involves its most important subjects - state and municipal authorities. As well as commercial and non-profit organizations that contribute to digitalization directly, for example, through the introduction of digital technologies in economic activities to provide services to the population, or indirectly, for example, by teaching older people how to use computer equipment (Sepe, 2014; Rodrigues & Franco, 2021).

Initial studies on megacities development are based on research about rural and urban differences and the process of urbanization. Lin (2001) underlined that differences between the economy of rural and urban areas were based on quantitative factors such as population growth or spatial characteristics. However, the development of urban and rural areas cannot be explained by quantitative data only as the change in the population size. Moreover, he underlines that the urbanization process is dependent on the condition. For instance, the case of agglomerations or business organizations development in China was in rural areas through the development of villages. Even though population growth as a quantitative factor cannot be accepted as the primary factor for megacities development, it still has played a significant role.

Moreover, another factor for megacities development in rural areas expansion. There are two ways in which rural areas influence megacities development, which is mostly discussed in the literature. The first one is the high rate of internal migration of the rural population to cities, which is caused mainly by unemployment,

poor social policy and lack of industry development. The second one is high birth rates in rural areas, mostly observed in the post-war period. The population growth factor has built a link between urban and rural areas (Morrill, 2006).

Among mechanisms of megacities development, there could be underlined informal economy as it contributes to the employment rate of the population. Therefore, official statistics showing a high unemployment rate must show an accurate picture. At the same time, the informal economy stands out as a negative development for megacities' evolution. This is because agglomerations are the most significant economic development engine due to the combined characteristics of industry development, population size growth, innovation and technology development potential. An informal economy causes a reduction in the revenue of any city or village, as the state budget highly depends on the GRP of regions.

At the same time, megacities' downfall is a regress factor for economic development, as one of the primary goals of a government is to support agglomerations. From a political perspective, megacities depend highly on the market because industry development affects state policy and regulations. Therefore, efforts to recover urban areas slow down or prevent economic growth. Therefore, industry development predicts megacities development, which explains the difference in various factors that influence economic development over time (Logan & Swanstorm, 2005). For instance, the development and application of information communication technologies in every aspect of industry-focused, the labor market to the development of ICT skills and seeking for qualified personnel in technologies among local population and officials. Consequently, the private sector requirement conditions the state authorities to encourage training new skills in rural and urban areas, which is also achieved through distance learning programs (Bada & Madon, 2006).

Consequently, the urbanization process of previous years differs from the modern one. If earlier works considered urbanization as the process of population migration and population growth, current studies have focused their attention on several directions. Apart from demographic factors, economic development has overwhelmed the development of megacities. Development of and wide use of innovations, ICT and digital technologies and the increase

of entrepreneurship have significantly affected the process of urbanization and, thus, megacities development (Kourtit & Nijkamp, 2013).

The development of megacities ensures sustainable economic development of the region. Among the main features of megacities are highly developed infrastructure, innovation development and technological development and the emergence of business organizations, new markets, etc. Digitalization of economic processes and city infrastructure functioning are primary drivers of the sustainable development of megacities (Li et al., 2018; Kozlov et al., 2020). Due to the development of Industry 4.0, Megacity is considered another form of digital hub. This is explained by the fact that the current digitalization process has become an essential part of the cities' infrastructure as transport logistics, delivery of services and industries development are provided through digital tools and require adequate labor force and capacity of urban areas. Megacities are highly populated areas, and a proper strategy for quality city management is essential daily, challenging or, in current conditions, only possible with digital technologies (Safiullin, 2019).

Moreover, ICT, technological development, and the capacity of a region to implement innovations play a significant role in the development of large cities. The positive impact of digitalization on the development of the economy is primarily associated with the digital transformation of enterprises and industries. With an industry approach, the state and prospects for using ICT, the digital transformation of markets, and promising business models in digitalization are analyzed. There are five successive stages of digital transformation processes at the industry level, from primary informatization and communication digitalization to the industrial Internet. At the same time, digitalization affects inequality growth between rural and urban areas because the rural area has limited access to digital technologies. Thus, rural areas need more access to resources and remain low-qualified labor force regions in digitalization (Jiao & Sun, 2021).

The following stages of digitalization of enterprises could be identified that affect the dynamics of socio-economic processes at the regional level and substantiate strategic directions for the development of regions in the context of digital transformation of the economy. The stages include automation of technological processes; informatization of individual business processes (accounting, agreement of contracts,

design of products and technological processes, monitoring of relationships with partners and customers, etc.); complex informatization of the enterprise based on the integration of local information systems; integration into the digital economy ecosystem (Hrysenko et al., 2022). It is noteworthy that ICT is an essential part of digital economy development. Therefore, some studies consider organizations using computers, digital tools (e.g., cloud systems, big data etc.) and ICT users number, and organizations using innovative technologies as indicators of digital economy development (Huang & Chen, 2023).

Some authors assessed the main factors of innovation activity and concluded that the volume of investment, and with it, investment activity in the form of investment flows, is determined by many factors, including the development of ICT (Oleinik & Zakharova, 2016; Camboim et al., 2019). Recently, there has been an increase in scientific and practical interest in managing urban development during a pandemic (Kurochkin, 2020; Sharifi & Khavarian-Garmsir, 2020; Sovetova, 2021).

Bekenova et al. (2021) explored the relationship between economic development, particularly investment activity and digitalization in the megacities of Almaty, Astana, Shymkent in Kazakhstan. They considered digitalization as a factor in increasing the investment attractiveness of these cities. In addition, digitalization has a positive effect on Almaty and Astana, and the strategy for the improvement of the digital infrastructure of Shymkent needs to be developed.

All authors, with some non-critical differences, agree that digitalization is introducing digital technologies into socio-economic processes to improve the living conditions of residents of cities and towns. GRP indicators, average monthly wages, average life expectancy, population and others assess the main socio-economic processes.

Hypothesis 1: Digitalization of the city economy significantly influences domestic regional product (DRP).

The literature suggests that the digitalization of the economy can have a significant impact on economic growth (Maiti & Kayal, 2017). In the context of Kazakhstan, several studies have examined the relationship between digitalization and economic growth (Bulturbayevich & Jurayevich, 2021; Doszhan et al., 2021).

Additionally, Kazakhstan has contributed to the study of digitalization's impact on the economy. For instance, Alibekova et al. (2020) discuss two main streams of research on digitalization, one focusing on factors influencing ICT adoption and the other examining the role of ICT as a driver of economic growth, particularly in high-income and developing countries.

Hypothesis 2: Digitalization of the city economy significantly influences the average salary (wage).

The literature suggests that digitalization can have a significant impact on wages, as increased productivity leads to higher wages (Mokyr et al., 2018). In Kazakhstan, limited studies have examined the relationship between digitalization and wages. For instance, Georgieva et al. (2020) examined the impact of digitalization on Kazakhstan's economy, including its advantages such as increased GDP and venture financing. They proposed to consider the economy development strategy crowdfunding platforms as a tool for attracting private investment and outline the digital economy's main development directions, including competent regulation, infrastructure, and digital platforms.

Hypothesis 3: Digitalization of the city economy significantly influences the population change (POP).

The literature suggests that digitalization can significantly impact population growth, as seen in developing countries and Japan (Shibata, 2022). Limited studies have examined the relationship between digitalization and population growth in Kazakhstan. However, a study by Nurbossynova et al. (2021) found that digitalization had a positive impact on population growth in Kazakhstan's regions.

Hypothesis 4: Digitalization of the city economy significantly influences the change in life expectancy (L_{exp}).

The literature suggests that digitalization can significantly impact life expectancy, as seen in developing countries and China (Chen et al., 2021). In Kazakhstan, limited studies have examined the relationship between digitalization and life expectancy. In the context of Kazakhstan, there have been limited studies examining the relationship between digitalization and life expectancy.

Based on the literature review, it is essential to determine the strength and quality of the relationship between digitalization and socio-economic indicators.

The literature review showed that it is essential to study the relationship between average wage, digital population and change in the population size and life expectancy in the digital economy of a megacity. Thus, the study will conduct the study on an analysis of the influence of digitalization on social and economic indicators in megacities.

Research Methodology

The research methodology is based on the approach of Grachev (2021), the essence of which is to model digitalisation's impact on the national economy's socio-economic parameters. Hypotheses are put forward about the presence of a direct relationship between the mass introduction of network technologies on economic and social indicators. However, we use this method in the example of a metropolis, not a national economy. In addition, in this study, the sub-indicators necessary to calculate the digitalisation index of the city's economy have been changed.

A megacity is a city that merges many settlements into a single urban structure. Settlements located in territorial proximity to each other or even growing together with each other are called urban agglomerations. Therefore, a metropolis can be interpreted as a settlement formed from several urban agglomerations.

So, based on the definition and translation from ancient Greek, we will conclude that a Megacity is:

- a city with a population of more than a million people;
- a city formed from many settlements.

These in Kazakhstan include the city of Almaty. On the modern map of Kazakhstan, Almaty is among the most developed cities in the country. These cities are powerful scientific, intellectual, cultural, and financial centers, occupying leading positions in many sectors of the economy and social spheres. Statistics support the leading position of these cities. As the largest metropolis of Kazakhstan, Almaty is confidently moving in the wake of digital transformations. The level of digitalization penetration in Almaty is one of the highest in Kazakhstan: today, 96% of public services are provided in a digital format, which is constantly growing and positively impacts the economy.

In July 2022, Almaty, for the first time, entered the top five Asian cities in terms of readiness for digital development strategies, according to the world's leading research company, Thought Lab (New York). In Septem-

ber of the same year, Almaty became a finalist in the international IEEE Smart Cities Awards Contest.

For the assessment, data taken from the official website of the Bureau of National

Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan from 2016 to 2021 was used. The list of indicators for calculating indices and critical assessments for digitalization is given in Table 1.

Table 1 - Coding indicators

No.	Indicator/ Sub-indicator	Indicator code
Independent indicator		
	Digitalization of the city economy	DIG_MP
1	Business digitalization	Dig_Biz
1.1	Number of enterprises using digital technologies	X1
1.2	Number of computers used in enterprises	X2
1.3	Number of own data centers	X3
1.4	Number of servers	X4
1.5	Number of storage systems	X5
1.6	Number of enterprises with ICT specialists	X6
1.7	Number of businesses with Internet access	X7
2	Population number	Dig_P
2.1	Share of Internet and computer users aged 16-74, %	P1
2.2	The proportion of households using broadband via cell phone, %	P2
3	Costs for the implementation and use of digital technologies, KZT	Ex_dig
Dependent indicators (socio-economic)		
4	Domestic regional product, KZT	DRP
5	Average monthly salary, KZT	Wage
6	Population number	Pop
7	Average life expectancy, years	L_exp

Note: compiled by authors

This study will apply quantitative analysis based on secondary data. In addition, the study will be carried out in three stages:

1. Data analysis;
2. Calculation of indicators;
3. Correlation analysis.

To determine the relationship between digitalization and socio-economic indicators, it is necessary to determine the index of digitalization of the city's economy, which is calculated as the sum of three indicators:

$$DIG_MP = Dig_Biz + Dig_P + Ex_dig \quad (1)$$

Where the Dig_Biz is an indicator of business digitalization;

Dig_P - digitalization of the population;
Ex_dig - financial support for digitalization

Each of these indicators consists of several indicators:

1. Business digitalization consists of the following indicators:

- Number of enterprises using digital technologies (X1);
 - Number of computers used in enterprises (X2);
 - Number of own data centers (X3);
 - Number of servers (X4);
 - Number of data storage systems (X5);
 - Number of enterprises with ICT specialists (X6);
 - Enterprises with access to the Internet (X7).
- Calculated according to the formula:

$$Dig_Biz = (X1+X2+X3+X4+X5+X6+X7)/100 \quad (2)$$

2. Population (PD) - includes the following indicators:

- number of active subscribers of fixed broadband access to the Internet (BBAI);

- the number of active subscribers of mobile broadband access to the Internet (MI).

Calculated using the following formula:

$$\text{Dig}_P = (P1+P2)/100 \quad (3)$$

Data for indicators will be used from open sources, such as the Bureau of National Statistics of the Republic of Kazakhstan, from 2016 to 2021. After that, the relationship between the digitalization of the city's economy and socio-economic indicators will be considered by calculating the correlation for the city of Almaty. Socio-economic indicators include:

- average salary (AS);
- population;
- domestic regional product (GRP);
- life expectancy (LE).

The following hypotheses were developed:

Hypothesis 1: Digitalization of the city economy significantly influences domestic regional product (DRP).

Hypothesis 2: Digitalization of the city economy significantly influences average salary (wage).

Hypothesis 3: Digitalization of the city economy significantly influences the change in the population (POP).

Hypothesis 4: Digitalization of the city economy significantly influences the change in life expectancy L_{exp}).

Analysis and results

Almaty is among the most developed cities in the country. These cities are powerful scientific, intellectual, cultural, and financial centers, occupying leading positions in many sectors of the economy and social spheres. One of the seven main priorities in the strategy of the adopted City Development Program is the creation of "Almaty - Smart City". By the end of 2023, it is planned to start creating a "digital twin" of the city, similar to such megacities as Singapore and Shanghai. Significant projects for the further development of Almaty are other systemic platform solutions that will improve the management of the city. This is the Unified data warehouse of the city, the Unified geo-analytics platform. It is planned that 2023 the Unified Video Monitoring System will cover up to 80% of the city of Almaty. Thus, with the help of digitalization, a comfortable urban environment is created, and the safety of citizens and guests of the city is ensured.

To calculate the digitalization index for Almaty, we use data from open sources from 2016 to 2021, shown in Table 2.

Table 2 - Indicators of the digitalization index

No.	Indicators	2016	2017	2018	2019	2020	2021
1	Number of enterprises using digital technologies (X1)	26715	27656	31793	31818	34443	35197
	Number of computers used in enterprises (X2)	254 411	237522	235142	275 464	283 677	300014
	Number of own data centers (X3)	92	1061	312	561	897	419
	Number of servers (X4)	12834	18970	14609	13 93	12674	14104
	Number of storage systems (X5)	3812	4713	5056	6333	6606	5176
	Number of enterprises with ICT specialists (X6)	3 178	2547	3788	3628	3 797	3 267
	Businesses with Internet access (X7)	22 384	21 438	24 199	26 255	29 782	27 115
	Dig_Biz	3234,26	3139,07	3148,99	3440,59	3718,76	3852,92
2	Share of Internet and computer users aged 16-74 (P1)	86,2	87,1	87,7	89,5	92,9	94,3
	Proportion of households using broadband via cell phone (P2)	53,3	64,6	63,9	76,9	79,4	76,3
		Dig_P	1,395	1,517	1,516	1,664	1,723
3	Ex_dig	1061,033	1722,716	530,883	813037	839406,9	939884,3

Note: compiled by authors

In Table 2, sub-indicators of the digitalization index were provided, such as digitalization of business and digitalization of the population, in this table they are calculated using formulas (2) and (3). Next, the indicator of digitalization of the metropolis economy is calculated (see Table 3).

Table 3 calculates the digitalisation indicator of the megacity economy, where formula (1) is used. Next, the relationship between the DIG_MP indicator and the socio-economic indicators of the city will be considered.

In order to assess the potential level of effectiveness of the digitalization of urban space, a collection of socio-economic indicators of Almaty was carried out in Table 4.

Table 3 - Calculation of the index of digitalization of the economy of the megacity (DIG_MP) Almaty

	2016	2017	2018	2019	2020	2021
Dig_Biz	3234,26	3139,07	3148,99	3440,59	3718,76	3852,92
Dig_P	1,395	1,517	1,516	1,664	1,723	1,706
Ex_dig	1061,033	1722,716	530,883	813037	839406,9	939884,3
DIG_MP	4296,688	4863,303	3681,389	816479,2	843127,4	943739

Note: compiled by the authors

Table 4 - Socio-economic indicators of Almaty city for 2011-2021

№	Indicators	2016	2017	2018	2019	2020	2021
1	DRP, KZT	10 601 347,8	11 893 225,9	12 132 649,7	13546958,4	13459802,6	15000060
2	Pop	1 702 766	1 751 308	1 801 993	1 854 656	1 916 822	1 977 258
3	Wage, KZT	212 848	227 003	240 320	266 796	302 504	344 691
4	L_exp, years	75,1	76,21	75,54	75,45	74,02	71,97

Note: compiled by the authors

The data shows that the city's domestic and regional products grew by 309% during the period analyzed. Moreover, the population increased by 39%, from 1,415.5 million to 1,977.2 million people. The average salary has increased by 2.5 times. These indicators show a steady growth of socioeconomic indicators in the city. However, life expectancy positively increased until 2017, when the indicator had the highest level and reached 76.21 years. However, there was a decline after that, which led to 71.97 years in 2021. This is a consequence of the ecological and epidemiological environment in the city. Life expectancy is one of the leading indicators of quality of life, essential in assessing socioeconomic development. Judging by this indicator in Almaty, it is necessary to think about the health and ecology problems of the city.

The analysis of the data also reveals important socioeconomic indicators in the city, showing significant growth in domestic and regional products by 309% during the analyzed period. The population also experienced an increase of 39%, reaching 1,977.2 million people, and the average salary increased by 2.5 times. These positive trends indicate overall socioeconomic development in Almaty city.

However, it is noteworthy that while life expectancy initially showed an upward trend, reaching its highest level of 76.21 years in 2017, there has been a decline in recent years, with a decrease to 71.97 years in 2021. This decline could be attributed to ecological and epidemiological challenges faced by the city, highlighting the importance of considering health and environmental issues in the context of digitalization and socioeconomic development.

Life expectancy is a crucial indicator of the quality of life and reflects the overall well-being of a population. The declining trend in life expectancy in Almaty raises concerns and emphasizes the need to address health and ecological challenges to ensure sustainable and inclusive development.

In conclusion, while the socio-economic indicators such as economic growth, population increase, and higher salaries indicate positive developments in the city of Almaty, the declining trend in life expectancy underscores the need for further investigation and actions to address health and ecological issues for a holistic approach towards sustainable socioeconomic development. Next, there regression analysis was conducted. Table 5 there is provided a models summary of the four hypotheses.

Table 5 - Four models: model summary

Model summary				
Model/variable	R	R-sq	Adj. R-sqr	Std. Err. Estim.
1 Constant: DRP	,899 ^a	,809	,761	755069,3811785806000
2 Constant: Wage	,892 ^a	,795	,744	25338,964
3 Constant: POP	,903 ^a	,815	,769	49462,466
4 Constant: L_exp	,718 ^a	,515	,394	1,19126
Independent variable: DIG_MP				

The analysis involved four different models, and the summary of their results revealed that the R-square values for the first three models were high, indicating that a large portion of the changes in the dependent variable, DIG_MP, could be explained by the independent variables. Specifically, the variable DP had an R-square of -89.9%, Wage had an R-square of 89.2%, and POP had an R-square of 90.3%. This suggests that these three variables had a strong explanatory power with DIG_MP.

On the other hand, the variable L_exp showed comparatively lower results, with an

R-square of only 71.8%. This indicates that this variable had less influence on explaining the changes in DIG_MP compared to the other three variables.

In summary, the analysis showed that DP, Wage, and POP had higher explanatory power about DIG_MP, while L_exp had comparatively lower explanatory power. Further analysis and interpretation may be needed to understand the implications of these results and their significance for the research or study being conducted. In Table 6, there are presented results for Anova analysis.

Table 6 - Four models: Anova

ANOVA						
Model/variable		Sum Sqr.	df.	Mean Sqr.	F	Sig.
1 DRP	Regression	9650108222034,215	1	9650108222034,215	16,926	,015 ^b
	Residual	2280519081573,618	4	570129770393,405		
	Total	11930627303607,832	5			
2 Wage	Regression	9961997170,037	1	9961997170,037	15,516	,017 ^b
	Residual	2568252415,297	4	642063103,824		
	Total	12530249585,333	5			
3 POP	Regression	43107536758,979	1	43107536758,979	17,620	,014 ^b
	Residual	9786142025,854	4	2446535506,463		
	Total	52893678784,833	5			
4 L_exp	Regression	6,031	1	6,031	4,250	,108 ^b
	Residual	5,676	4	1,419		
	Total	11,707	5			

Dependent variable: DRP, Wage, POP, L_exp

Independent variable: DIG_MP

Note: compiled by authors

The results for the Anova analysis for all four models showed the following. The F value for the first four models is high, which shows that the difference between the variables is high and excludes collinearity. The first three models'

P-values are significant and less than 0.05 ($p < 0.05$): DRP = 0.015, Wage = 0.017, POP = 0.014. Thus, the hypotheses one, two and three are accepted.

According to the hypotheses, the digitalization process positively influences the increase

in the population’s income, digital population and population increase. Early studies show that economic digitalization creates new jobs and new markets, which is especially could observed among university graduates (Zemtsov et al., 2019). However, some studies point that digitalization process favors industrial automation, which tends to the increase the human capital replacement by machines. Therefore, there is high possibility that people with low digital knowledge are at higher risk of losing jobs. Conversely, educated half of the population are in more demand and their income increases (Vasilescu et al., 2020). This explains the increase in the population size in urban areas, particularly megapolises.

However, the F value for the LE model is low (4,250), which shows that the collinearity rate is high. Thus, the model is insignificant. Moreover, the significance of the model LE is more than 0.05 ($p>0.05$). Hypothesis four is rejected, thus digitalization of the economy has insignificant impact on the life expectancy of the population. This area of studies currently is attracting attention of the scientific world. The digital economy has an indirect impact on the life expectancy, because is affects the economic growth. This also includes industrial development and promotes development of existing industries and creation of new markets. Therefore, it has impact on the environment. According to the context of the study, the results can be different. For instance, there is positive correlation between digitalization of the economy, access to finances and CO2 emission by industries. At the same time, the development of digital infrastructure allows careful usage of water resources and

avoids excessive consumption of drinking water reservoirs (Rosário & Dias, 2022).

The analysis summary reveals that the first three models, which included the variables DP, Wage, and POP, showed significant results with high R-square values and low P-values, indicating that these variables had a significant influence on explaining the changes in DIG_MP. This supports the acceptance of hypotheses one, two, and three, which suggest that the digitalization process has a positive impact on the income of the population, digital population, and population growth.

However, the fourth model, which included the variable L_exp, showed lower results with a higher P-value, indicating that this variable had an insignificant impact on explaining the changes in DIG_MP. This leads to rejecting hypothesis four, which suggests that the digitalization of the economy has an insignificant impact on the population’s life expectancy.

It is worth noting that the collinearity rate was high for the LE model, which may have affected its significance. The findings also suggest that the impact of digitalization on various aspects, such as job creation, human capital replacement, population growth, and environmental factors, may vary and require further investigation.

Overall, this analysis provides insights into the relationship between digitalization and its impact on the economy, population, and life expectancy. However, further research and consideration of other relevant factors are necessary to fully understand the complex dynamics of digitalization and its implications in different contexts. Table 7, there are presented results for the analysis of the coefficients.

Table 7 - Four models: coefficients

Coefficients						
Model/variable B		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Err.	Beta			
1	DRP	11496687,416	437221,038		26,295	,000
	DIG_MP	2,926	,711	,899*	4,114	,015
2	Wage	224707,266	14672,464		15,315	,000
	DIG_MP	,094	,024	,892*	3,939	,017
3	POP	1748874,256	28641,117		61,062	,000
	DIG_MP	,196	,047	,903*	4,198	,014
4	L_exp	75,740	,690		109,800	,000
	DIG_MP	-2,313E-6	,000	-,718	-2,062	,108

Dependent variable: DRP, Wage, POP, L_exp

Note: compiled by authors

The coefficients analysis showed that there is a significant positive correlation between the independent variable DIG_MP and dependent variables DRP (.015), Wage (.017) and POP (.014). The coefficients analysis reveals important findings regarding the relationships between the independent variable DIG_MP and the dependent variables DRP, Wage, and POP. Specifically, the analysis demonstrates a significant positive correlation between DIG_MP and each of these dependent variables. The correlation

coefficient for DRP is .015, for Wage, it is .017, and for POP it is .014. These results suggest that as the value of DIG_MP increases, there is a corresponding increase in the values of DRP, Wage, and POP. This positive correlation indicates that higher values of DIG_MP are associated with higher values of the dependent variables, indicating a potentially favorable impact of DIG_MP on DRP, Wage, and POP.

Table 8 presents correlation analysis for all variables used in the model.

Table 8 - Four models: correlation analysis

		Correlation				
Model/variable		DIG_MP	DRP	Wage	POP	L exp
DIG_MP	Pearson correlation	1	,899*	,892*	,903*	-,718
	Sig. (two-tailed)		,015	,017	,014	,108
	N	6	6	6	6	6
DRP	Pearson correlation	,899*	1	,949**	,969**	-,755
	Sig. (two-tailed)	,015		,004	,001	,083
	N	6	6	6	6	6
Wage	Pearson correlation	,892*	,949**	1	,984**	-,903*
	Sig. (two-tailed)	,017	,004		,000	,014
	N	6	6	6	6	6
POP	Pearson correlation	,903*	,969**	,984**	1	-,825*
	Sig. (two-tailed)	,014	,001	,000		,043
	N	6	6	6	6	6
L_exp	Pearson correlation	-,718	-,755	-,903*	-,825*	1
	Sig. (two-tailed)	,108	,083	,014	,043	
	N	6	6	6	6	6

*. The correlation is significant at the 0.05 level (two-tailed).

**.. The correlation is significant at the 0.01 level (two-tailed).

Note: compiled by authors

The correlation analysis provides valuable insights into the relationships between various variables. Specifically, the results indicate significant positive correlations between Population and DIG_MP (0.903), DRP (0.969), and Wage (0.984). This suggests that as the Population increases, there is a corresponding increase in the values of DIG_MP, DRP, and Wage. Additionally, DRP shows significant positive correlations with DIG_MP (0.899), POP (0.969), and Wage (0.949), indicating that as DRP increases, there is a corresponding increase in the values of DIG_MP, POP, and Wage.

Furthermore, the analysis reveals significant negative correlations between Life expectancy and Wage (-0.903) and Population (-0.825). This indicates that as Life expectancy decreases, there is a corresponding decrease in the values of Wage and Population, suggesting a potentially adverse impact on these variables.

These correlation results provide essential insights into the relationships between the variables, suggesting potential patterns and trends. The findings from the correlation analysis highlight the interdependencies between Population, DIG_MP, DRP, Wage, and Life expectancy in the context of the studied variables.

The significant positive correlations suggest that as Population and DRP increase, there may be corresponding increases in DIG_MP, POP, and Wage. Conversely, the negative correlations between Life expectancy and Wage and Population suggest that a decrease in Life expectancy may be associated with lower values of Wage and Population.

These findings can inform urban planning, economic development, healthcare, and data-driven decision-making in the studied context. However, it is important to note that correlation does not imply causation and further research is needed to establish causal relationships and understand the underlying mechanisms driving these correlations.

In light of these findings, policymakers, local authorities, and stakeholders in the context of Almaty, or any relevant study or research, should carefully consider these relationships and their implications for informed decision-making. Future studies could utilize more advanced statistical methods, longitudinal data, and qualitative analysis to explore the complex dynamics further and develop a more comprehensive understanding of the relationships between these variables. Overall, the correlation analysis provides valuable insights for policymakers and researchers to understand the associations between the variables better and make evidence-based decisions to promote sustainable urban development and well-being in the studied context.

The research results showed that digital economy development in megacities impacts economic growth by creating new markets and attracting human capital. The digital economy contributes to the income increase, but it must be mentioned that it is favorable for the education population. This is mainly related to human capital with good digital skills and qualifications.

On the other hand, economic digitalization brings industry development and impacts the environment by reducing or increasing the pollution level. Therefore, the context of megacities' digitalization is also essential.

To summarize, there were four hypotheses: three were accepted, and one was rejected. Economy digitalization has a significant impact on the productivity of a region and creates new working places and new markets. At the same time it can contribute to the population increase or can reduce the number of the employed population. Economy digitalization has an indirect impact on life expectancy as it can have either a negative or positive impact on the environment.

Conclusion

This article aimed to explore the impact of digitalization in megacities on its socio-economic indicators using the example of Almaty city. Analyzing the dynamics of the components of the digitalization index of the metropolitan economy, it should be noted that all three indicators showed growth throughout the period under consideration from 2016 to 2021.

Hypothesis 1, 2 and 3 were accepted. Economy digitalization involves complex processes of new market development, including industrial and labor markets. First, digitalization process is directed at the automation of the production processes. This requires attracting human capital with digital skills and simultaneously promotes unemployment among the low-educated population. Low educated population or population without digital skills, in the context of economy digitalization struggle to maintain jobs. While students graduates are in more demand as they have gained new digital knowledge and can adapt to economic transformation. The emergence of new markets creates opportunities and thus promotes labor force migration, which influences the change in population size. Thus, based on the context economy, digitalization can have a significant impact if the economic transformation context is more ready for the digitalization process. Rapid change to digitalization can cause high unemployment rates and increase social inequality among the population. Therefore, the process of economic digitalization is highly dependent on the context.

Hypothesis 4 was rejected. Economy digitalization relationship with change in life expectancy is indirect as it affects the environmental condition. It is reflected in the impact of industrial development. Industry development increases productivity and affects the consumption of natural resources and pollution levels by industries. Digitalization in megapolises involves all sectors of the economy and city infrastructure. Therefore, economic digitalization strongly impacts the social and economic indicators of megapolises.

Summing up the study, it should be summarized that despite the close attention to digitalization by both domestic and foreign scientists, the problem of analyzing and modelling this process is very relevant. As part of this work, the problem of modelling individual parameters of the socio-economic development of such a metropolis as Almaty in the context of

digitalization was touched upon. Based on the results obtained, it is possible to predict both economic and social consequences of the mass introduction of network technologies in production and everyday life. Positive dynamics were identified and described in terms of population, GRP per capita, and average monthly wages. In addition, a high negative relationship with life expectancy was found.

Future studies can focus on the impact of economic digitalization on environmental pollution based on the context. The research showed that results are only sometimes possible to generalize. Therefore, context-based studies of the economy digitalization and environmental pollution are essential.

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