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Research Article

The impact of digital transformation on the sustainable development of the Azerbaijani economy

Nariman Hajiyev [1]*, Vilayat Ismayilov[2], Gulnara Fataliyeva[3], Lala Mahmudova[4], Sabina Asadova[5]

[1]Azerbaijan State University of Economic, Baku, Azerbaijan,
* **Corresponding Author Email:** narimangd@yahoo.com - **ORCID:** 0000-0001-6514-1065

[2]Azerbaijan Academy of Labor and Social Relations, Baku, Azerbaijan
Email: ismaylov1953@mail.ru - **ORCID:** 0000-0001-6514-1063

[3]Institute of Economics of the Ministry of Science and Education, Baku, Azerbaijan
Email: feteliyevagulya@gmail.com – **ORCID:** 0000-0001-6514-1062

[4]Azerbaijan Academy of Labor and Social Relations, Baku, Azerbaijan
Email: mahmudovalala2021@mail.ru - **ORCID:** 0000-0001-6514-1061

[5]Institute of Economics of the Ministry of Science and Education, Baku, Azerbaijan
Email: sabina_esedova@mail.ru – **ORCID:** 0000-0001-6514-1060

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Abstract:

The purpose of the study is to build a model of the impact of digital transformation on economic growth. The study reflects the changing different points of view of researchers explaining the impact of digital transformation on economic growth, as well as the impact of investment on GDP. Research theories Economic growth is a complex phenomenon, and theories must take into account all factors, including the volume of investments. The research methodology is based on research on digital transformation, economic growth, and investment. The data was collected using statistical materials on the economic growth of the countries of the world and the CIS. The impact of investments on the volume of Azerbaijan's GDP is also calculated. The factors influencing extensive and intensive ways of achieving economic development are revealed. We also identified indicators (quantity and quality of labor resources, availability of capital, technological level, quantity and quality of natural resources) characterizing the ability of economic growth. It is noted that the subjects of the economic system dealing with the business process need to undergo digital transformation and the factors determining the introduction of innovations in the field of information technology. The results of the study can be applied in determining the ways of economic development and maintaining its pace at an optimal level. The research contributes to the growth rate of the country's economy, thanks to the theoretical and practical results obtained. The relevance and value of the study is confirmed by its impact on the economy and investment.

1. Introduction

The digital economy is the force driving almost every industry. The digital economy is changing the way customers and corporations interact. As a result, everything changes: both the primary forms of capital and the distinctive features of the market. In the era of the digital economy, customers are much less concerned about logistics. Their area of interest is overall satisfaction with the use of the product. This shift is driven by direct day-to-day interaction with technology and the realization of resources associated with this interaction. The core technology of the fourth Industrial Revolution is focused on three areas: biological, physical, and digital [1]. Sometimes the digital economy is also called the" web economy", "new economy, "or "internet economy". We will consider in more detail the definition of the digital economy. The most popular definitions of "digital economy" are

Table 1. *Definition of the concept of "digital economy"*

№	The most popular definitions	Author	A source
1	The digital economy is a virtual environment that complements our reality. At the same time, virtual reality is still a product of human mental activity, and the advent of the computer has allowed it to be digitized.	Ivanov V.V.	[30, p.304]
2	The digital economy is an ecosystem defined by a set of devices, services, and technologies.	Dini P.	[7, p.26-29]
3	Digitalization is an important trend in the effective development of the digital economy. It is the basis of the digital economy and determines the restructuring of traditional information presentation formats into digital ones, in order to ensure the growth of business process efficiency and improve the quality of life.	Gnatyshina E. A.	[26, p.377-381]
4	Digital economy - digital artifacts and infrastructure for data transmission, storage and processing, users of systems, including social, economic, political, psychological and other factors affecting the implementation of interactions	Dong H.	[8, p.41-44]
5	The digital economy is a wide range of economic activities in which digitized data and knowledge are used as the main factors of production.	Ismayilov V.	[13, p.7-10]

presented below (Table 1). Modern research [2-10] identifies several components of the digital economy: - digital goods and services - goods produced using digital technologies and services provided in digital format; - goods and services, the production and provision of which depends on the development of information technology, for example, accounting services or complex technical projects; - IT industry, serving the previously discussed components of the digital economy, represented by manufacturers of network equipment and personal computers. Digital transformation is a process that reflects the use of digital technologies in general, and it ensures the integration of digital tools, data and technologies into all sectors of the economy. The transition to digital transformation aims to radically change and improve various aspects of operations, processes, products and services in the context of economic growth. As a result of the above, it is possible to achieve drastic and positive changes in the economic development of countries. Digital transformation refers to changes in the economic structure of a country, traditional markets, social relations, etc. It is also implied by the radical changes that have taken place in them.

Digital transformation is interconnected with the trend of changes in the new society that is gradually taking shape in the world. In this regard, the world is also experiencing problems related to digital technologies, climate change, the transition to a green economy, and processes such as ignoring the inevitable. And ignoring them cannot ensure that the country's economic growth trend is achieved [11]. Digital transformation is the introduction of modern digital technologies into the business processes of socio-economic systems at all levels. With the formation of digital transformation, there is a trend of changes in the new society and in the world, and these processes are associated with major problems that prevent economic growth. The approach to introducing modern digital technologies into this process implies not only the installation of modern hardware or software, but also fundamental changes in management approaches, corporate culture and external communications. As a result, the productivity of each employee and the level of customer satisfaction increase, and the company gains a reputation as a progressive and modern organization. In practice, this means creating a system of end-to-end business processes, which can be called a digital business ecosystem. Digital transformation is the introduction of modern digital technologies into the business processes of socio-economic systems at all levels [12]. With the formation of digital transformation, there is a trend of changes in the new society and in the world, and these processes are associated with major problems that prevent economic growth. The approach to introducing modern digital technologies into this process implies not only the installation of modern hardware or software, but also fundamental changes in management approaches, corporate culture and external communications. As a result, the productivity of each employee and the level of customer satisfaction increase, and the company gains a reputation as a progressive and modern organization. In practice, this means creating a

system of end-to-end business processes, which can be called a digital business ecosystem [13].

Digital transformation requires governments to implement innovative digital technologies, undergoing changes in accordance with modern requirements. The process of digitalization takes place at the level of the country, the enterprise and the population.

The process of digital transformation of the country's economy is always at the center of the state's attention. The development of its economic sectors is primarily due to the availability of a legislative framework. A number of documents of national importance have been adopted in Azerbaijan in connection with digitalization, transformation of the digital environment, etc. Among the documents considered important from this clan are the Decrees "On improving management in the field of digital transformation" [14] and "On some measures to improve management in the field of digitalization, innovation, high technologies and communications in the Republic of Azerbaijan" [6], which provide for the transformation of the economy into a digital environment and the expansion of digital services in the country, increasing transparency in this area, the introduction of digitalization and innovation.

To provide and expand digital services, a comprehensive ICT connectivity is required. In our opinion, the need for the ICT industry in the smart world of 2030 can be determined by four factors: - the ability to connect to the Internet in any case; - digital fund; - "Green" energy; - politics and the ecosystem. These factors are considered to have a direct impact on the digitalization process [14].

The supply and demand for ICT ensures the development of the digital economy. ICT provides access to use services that meet the needs of users. At the same time, helping industries to switch to digital technologies with increased productivity and lower costs. This contributes to the qualitative development of the digital economy. As demand stimulates an increase in new types of production activities, contributes to the creation of infrastructure and an increase in investment, employment and improves supply. The supply chain expands the production activities of ICT, develops and stimulates business innovation, increases production efficiency, creates market demand and stimulates consumption growth, thereby accelerating economic growth.

Most countries of the world prefer the introduction of innovative and effective use of digital technologies in their e-government activities. The main purpose of effective organization of this process is to ensure proper organization of reception, exchange of information and provision of services, effective use of digital services, involvement of people in the decision-making process and promotion of cooperation with them at a high level.

The direct involvement of government regulation of the economy also plays a crucial role in the effective organization of the process of transformation of the country's economy into a digital environment. The process of digital transformation depends on such factors as the priorities identified in the strategic plan for the development of industries adopted by the state, the formed legislative framework, etc. and requires appropriate changes.

2. Material and Methods

The article uses the method of comparative analysis to define the concept of digital transformation. The method of selecting factors influencing the rate of economic growth is also used. When developing regression models between the invested investments and the volume of GDP, a regression model was applied. When clarifying the country's rating on the global digital Index (GDI), the data selection method was used.

Also, using the analysis method, the change in economic growth in Azerbaijan over the period 2018-2024 was considered. To determine the adequacy of the model, it was tested on the basis of the Darbin-Watson criterion. Based on the analysis, relevant suggestions and recommendations are given at the end of the article.

3. Results and Discussions

3.1. Macroeconomic indicators and economic growth

Macroeconomic indicators are consolidated, averaged across the economy as a whole, indicators of production and consumption, income and expenses, structure, efficiency, welfare, exports and imports, economic growth rates, etc. Macroeconomic indicators allow us to form a general understanding of the processes and phenomena in the country's economy, as well as create the basis for the development and implementation of economic policy principles.

Macroeconomic indicators reflect the general level of development of the country's economy. These indicators are included in the group of the average value of production and consumption, the level of welfare of the population, income and expenses of the state. The most important macroeconomic factors that ensure economic growth include: -the volume of GDP (goods of material production and

services); -GDP (goods of both tangible and intangible production); -national income (the cost of all spent funds in GDP);-average labor productivity in the country; -the volume and structure of exports and imports; -the quality of people's lives (the population's needs for material and spiritual goods) [15].

3.2. Indicators characterizing the economy's ability to grow

A country's economic growth (or economic recession) is determined by an increase or decrease in both absolute and gross domestic product (GDP) per capita compared to the previous year. The following factors influence the rate of economic growth (Figure 1). There are two ways to achieve economic growth in countries (Table 2).

Economic growth cannot be continuous and uniform, it is affected by economic crises [16]. The economic development of a country is actually subordinated to economic cycles. Economic growth is also determined by numerous indicators. These indicators characterize the economy's ability to grow. A brief

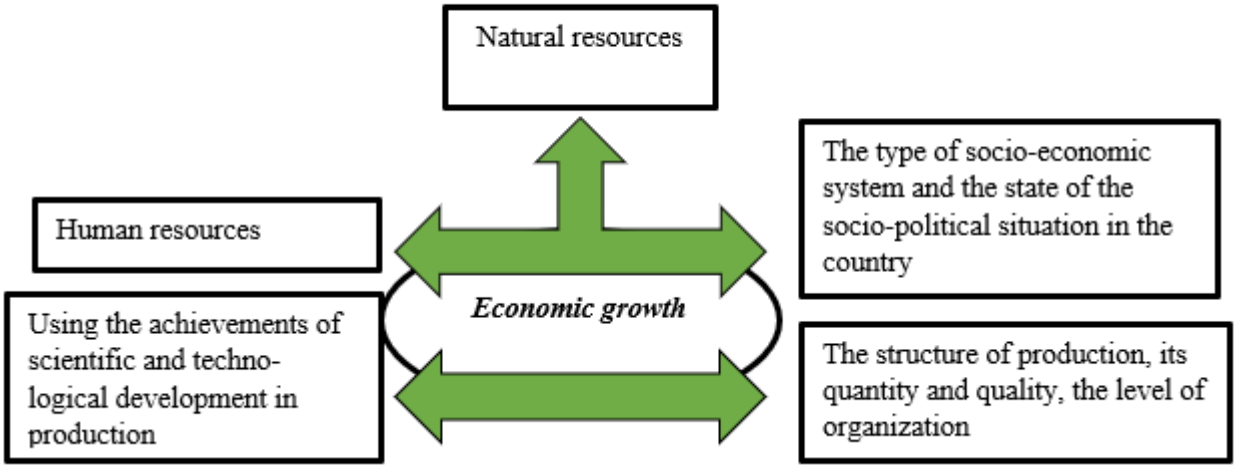

Figure 1. *Factors of economic growth* [1]

Table 2. *Ways to achieve economic development*

Ways to achieve	
Extensive	**Intensive**
GDP growth due to increased resource use: production includes unused resources available in the country: - increasing the number of mechanisms; - attracting auxiliary labor; - keeping the production technology unchanged; - increasing the area of cultivated land; - development of other deposits, etc.	GDP growth due to qualitative improvement of production factors and increased efficiency: - achievement of scientific and technical development; - savings due to expanded production with increased efficiency; - professional development of professional workers; - economical allocation of resources, for example, capital and labor move from inefficient industries to efficient ones

explanation of some of them is given below:

-Quantity and quality of labor resources: professional development of workers allows companies to increase productivity and labor efficiency, as well as achieve high results [17].

This factor is determined by the size of the country's population, some part of the population is not able-bodied and does not enter the labor market (pensioners, students, undergraduates, full-time doctoral students, etc.). An important role is played by the quality and labor costs in the production process. As the level of qualification (education) of employees increases, labor productivity increases, which increases the level of economic growth. Labor costs can increase without increasing working hours and the number of workers.

-Availability of capital. The fixed capital includes the housing stock, as people living in houses use the services provided by houses. This may seem common, but it is important to remember that economic theory considers all factors of production as providing productive services [18].

-Technological level. Technology development includes not only new production methods, but also new forms of management and organization of production, new information technologies. Technological development refers to the discovery of information that allows these resources to be combined in a new way to increase product output.

At the same time, new, efficient industries are being created. In practice, technological development and investment are linked: technological development requires investment in new machinery and equipment.

-Quantity and quality of natural resources. This factor is difficult to measure, although it has a significant impact on economic growth. For example, Azerbaijan has significant mineral reserves. Such a complex economy has a well-developed infrastructure and a powerful scientific and technical potential [16].

3.3. The process of digital transformation in business entities

Studying the process of digital transformation of the economy, Gribanov notes that in modern economic conditions, all economic entities of the socio-economic system are striving for sustainable functioning. These subjects are forced to undergo the process of digital transformation, which is schematically presented below (Figure. 2).

It can be seen from the figure that the subjects of the economic system dealing with the business process need to undergo digital transformation in the following sequence: -preliminary preparation (leadership management, modern circumstances, personnel and top management, business processes);-development (this is the transformation zone that it includes: software/ program platform, infrastructure, administrative and management personnel); -improvement (network control and digital economy, the specific weight of the service personnel) [19]. When performing their duties, business entities go through a transformation zone using the digital economy.

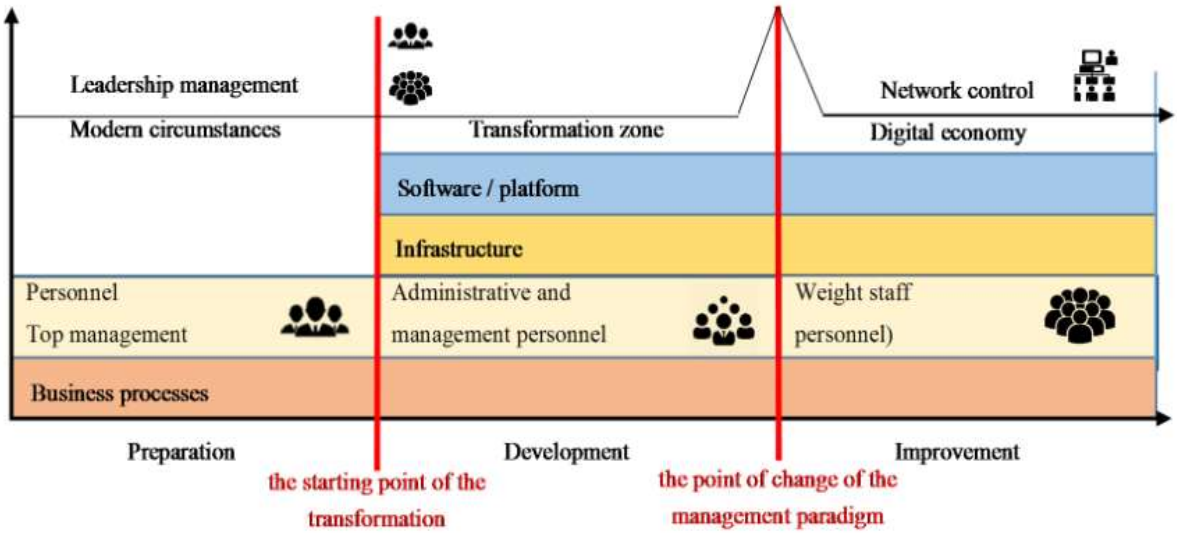

Figure 2. *The process of digital transformation in business entities* [18]

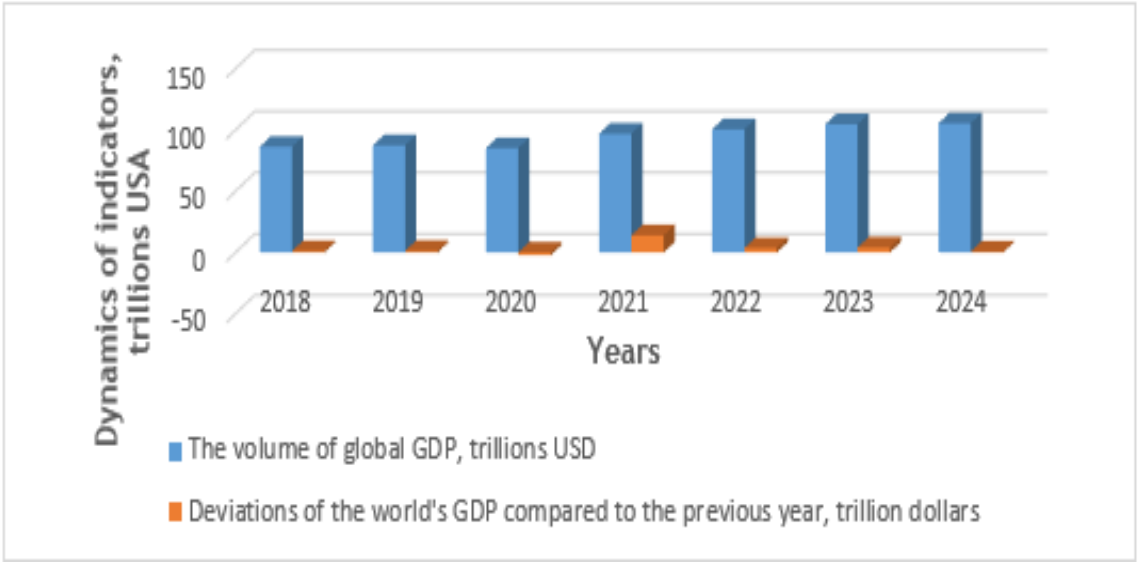

Figure 3. *Global GDP and the dynamics of deviation from 2018* [20]

The GDI reflects the movement of the ICT industry in the country, taking into account a larger number of indicators for digital infrastructure (including computing, data storage, cloud technologies and clean energy). Every year, according to the data of the countries of the world, a Global Digital Index (GDI) rating is compiled. GDI 2024 tracks the development of digital technologies in 77 countries and demonstrates a positive correlation between GDI and GDP. This list covers countries that account for 93% of global GDP and 80% of the world's population. The tracking results provide a good indication of the overall progress in global digital transformation. In 2024, Azerbaijan's GDI was 31.6 and its rating was 66 [14].

3.4. The relationship between digital innovation and economic growth

To analyze the links between digital innovation and the economic growth of countries, researchers propose two approaches: a factorial approach and an approach to the innovation process [21]. First of all, they consider the stages of innovation, consisting of discovery, implementation/ dissemination and impact, based on the theory of innovation dissemination (DoI).

As part of the implementation process, an innovative product or process is accepted if it occupies a leading position. Therefore, the DoI depends on the adoption mechanism by the developers. It is pointed out that the emerging economies of Asia remain the main driver of global growth. The volume of global GDP in 2018-2024 and the dynamics of deviation from 2018 are given below (Figure 3). Various theories describe the stages of the spread of innovation (Figure 4), but the DoI theory has been tested in practice, as it explains the phenomenon of the spread of innovation. The characteristics of innovation are confirmed by support for the spread of technological innovation and DoI, which is the most popular model for confirming the main characteristics of information technology (IT) implementation. The characteristics of innovation are confirmed by support for the spread of technological innovation and DoI, which is the most popular model for confirming the main characteristics of information technology (IT) implementation.

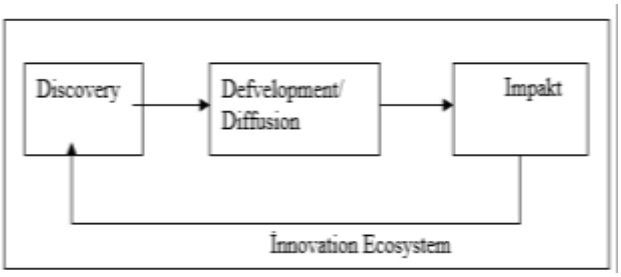

Figure 4. *Framework for digital innovation* [21]

The introduction of innovations in companies gives them the opportunity to increase productivity. And the innovations obtained through the introduction of technological changes provide advantages to industrialized countries with sustainable innovation systems that have set themselves the goal of accelerating economic growth [22].

3.5. A model of the relationship between GDP and investment

Progress towards prosperity occurs when Governments pursue policies that promote productivity, entrepreneurship, and innovation, and when they do so through closer international cooperation.

According to a report by the Organization for Economic Cooperation and Development (OECD), although global growth is showing signs of resilience, significant regional differences and current challenges remain. The data show that GDP in 2022 increased by $14.419 trillion or 16.7% compared to 2018, by $18.441 trillion or 21.4% in 2023, respectively, and by $19.213 trillion or 22.3% in 2024. The most significant deviation of global GDP compared to the previous one was in 2021 (13.918 trillion dollars), and the lowest deviation corresponded to minus 2.24 trillion dollars in 2020. Also, Azerbaijan ranks 6th among the CIS countries in terms of GDP (180.8 billion dollars) [15, 23-29].

Table 3. *Factors determining the introduction of innovations in the field of information technology*

№	Factors	Information technology fields
1	İnnovation Characteristics	Relative Advantage, Compatibility, Complexity, Observability, Communicability, Divisibility,Profilability, Soscial Approval, Managerial Productivity, etc.
2	Organizational Characteristics	Top Management Support, Organization Size, Organization Readiness, Centralization, Formalization, IS İnfrastructure, IS Investment, Training, Culture, Earliness Adaption, Perceived Barrier, etc.
3	Environmental Characteristics	External Expertise, Consultant Effectiveness, Globalization, Social Influence, Government Support, Environmental Uncertainty, etc.

After the restoration of independence, Azerbaijan began to develop, and GDP growth by PPP averaged 6.1% in 2013-2023. And the average GDP growth rate for this period was 0.62% higher than the global total. The statistics presented in the table show that for 2018-2024, The country's economy has seen positive trends in investment and GDP growth.

The study revealed the relationship between GDP and investment in the Republic of Azerbaijan. In general, the regression model is expressed by the formula (1):

$$Y=a_0x_0+a_1x. \qquad (1)$$

To solve the problem, it is usually assumed that $x_0=1$.

Using the "Vizual Studio Code" program, the interaction between total GDP and invested investments for 2018-2024 was clarified. It was also determined in the coefficient a_0, a_1, and $\hat{y}$, R^2, S_e, DW the following indicators:

$a_0=47.1966$; $a_1=2.9276$; $R^2=0.78616$; $S_e=4.46651$; DW=1.7985

By taking these coefficients into account and showing Formula (1), it will be like this:

$$\hat{y}=a_0x_0+a_{1x}=47.1966+2.9276x_1. \qquad (2)$$

Figure 5. *The relationship between the volume of GDP and investments*

Using the above program, we obtained an individual value (y), which is shown in Table 4. Figure 5 shows the relationship between GDP and investments over the period under review.

The Darbin-Watson criterion is used to test the hypothesis that there is no autocorrelation in the resulting model. The Darbin-Watson criterion (DW) is an indicator of the adequacy of the model. In practice, the hypothesis H_0 about the absence of autocorrelation of residuals is verified by comparing the statistics of DW with the theoretical values of d_L and du for a given number of observations n =7, the number of independent variables of the model k =1, and the significance level α. When calculating based on data from a certain period, we chose the theoretical values of $d_L=0.497$ and $d_u=1.003$ in the case of α=0.01 (1%). Also, it was determined at the significance level of the statistical quantities' d_L =0.76 and $d_u=1.33$ in the case of α=0,05 (5%) [29].

At the same time, three hypotheses of the autocorrelation residue in the model were tested:

1. When $DW>d_L$, the hypothesis is rejected in the absence of a true autocorrelation residue.
2. In the case of $d_L\leq DW\leq d_u$, the hypothesis remains open.
3. When $DW > d_u$, u is taken as a hypothesis.

If we look at the hypothesis, $DW >d_u$, or 1.7985>1.003, at the level of α =0.01 (1%) of the Darbin-Watson criterion, the absence of an autocorrelation balance in the real price is assumed. Also, at the level of α=0.05 (5%), then $DW >d_u$, or 1.7985>1.33, the absence of an autocorrelation residue in the real value is also assumed.

Thus, the change in GDP and its projected value in Azerbaijan from the volume of investments can be calculated based on long-term data in the situation under consideration. Note that the model justifies itself in determining the relationship between the volume of GDP and investments in any country.

The state of the economy can be assessed using a number of indicators, such as inflation (the purchasing power of money decreases), the key interest rate (affects interest on loans and deposits), GDP (the cost of all goods and services produced in the country per year), unemployment and the inversion of the yield curve [28].

In the era of the Fourth Industrial Revolution, artificial intelligence, and digital transformation, the impact of these significant changes on the

Table 4. *Data on the volume of GDP and investments in Azerbaijan for 2018-2024* [4]

Years	Volume of GDP, (Y), trillion dollars	The volume of investments made, (In), billion dollars	Individual value (ŷ)
2018	86.222	15.2217	91.76
2019	87.479	14.6981	90.2271
2020	85.239	13.2259	85.9171
2021	96.967	14.8904	90.7901
2022	100.641	17.1383	97.3711
2023	104.663	18.8711	102.4441
2024	105.435	20815.4	108.1363

functioning of the economy is of serious concern to both economists and policy makers. Using Bayesian linear regression, the authors studied the relationship between digital transformation, economic development, productivity and employment in 155 countries, the data obtained indicate a positive relationship between digital transformation and economic development [28].

The researchers argued that the development of digital technologies has a positive effect on economic growth and tried to study the positive impact of digital evolution on economic growth using Pearson correlations and F-statistical analysis. Based on the conducted research, it turned out that the development of digital technologies has a positive impact on the economic growth of EU member states [4].

Research conducted in Azerbaijan in the field of the use of ICT in enterprises shows that in 2010-2025 there were significant improvements in providing enterprises with computers and the Internet. But in general, the indicators of the level of use of information and communication technologies (ICT) in enterprises and employees of enterprises are low [30]. And the introduction of computers and the Internet into the activities of enterprises eventually leads to qualitative changes in their work. As this process has a positive effect on increasing the competitiveness of the enterprise. Therefore, the acquisition of ICT is important in terms of improving the quality of services and their modernization in the country. The access of employees working for companies to computers and the Internet should also be expanded.

Digital transformation encourages additional investments in the development of business experience and competencies of employees, improving their culture of working with data. Because through investments invested in training, it can allow employees to acquire new knowledge and implementation skills at work. Investments in improving the knowledge and skills of staff are one of the most important criteria for digital transformation. In this regard, one of the important requirements of the existing labor market is to increase investments in order to integrate workers into digital technologies.

In order to maintain Azerbaijan's competitiveness in the international arena and its innovative development, it is important to align its policy with the requirements of digital transformation. For this, first of all, security in cyberspace must be ensured. That is, since the digitization process is fast, cybersecurity of digital systems and networks must be ensured accordingly. Digital Transformation is used in different applications [31-33].

4. Conclusions

Having analyzed the role of the digital economy in the development of the country's economy, we can identify the following areas: -achieving digitization and improving the digital environment by ensuring the transition of companies engaged in business processes to digital transformation to increase their competitiveness in local, regional and foreign markets.

It is revealed that the subjects of the economic system dealing with the business process need to undergo a digital transformation. The factors determining the introduction of innovations in the field of information technology are highlighted, and when performing their duties, business entities go through a transformation zone using the digital economy.

With the help of the Visual Studio Code program, the relationship between the volume of GDP and investments for 2018-2024 in Azerbaijan has been determined. To determine the adequacy of the model, it was tested based on the Darbin-Watson criterion and appropriate suggestions and recommendations are given at the end of the article.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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