REPUBLIC OF AZERBAIJAN

On the rights of the manuscript

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

DIGITAL AND INNOVATIVE TRASFORMATION OF AZERBAIJAN TRANSPORTATION ECOSYSTEM

Speciality: 5306.01 – Technological innovation economy
5312-01 – Field economy

Field of science: Economical studies

Applicant: **Elvin Vugar Alizade**

Baku – 2025

The work was performed at the faculty of Economy and statistics of Azerbaijan Technological University

Scientific supervisor: Doctor of Economic Sciences, professor
Vilayat Mammad Valiyev

PhD in Technical Sciences, associate professor
Fuad Samid Dashdemirov

Official opponents: Doctor of Economic Sciences, professor
Rovshan Shahbaz Muradov

PhD in Economics, associate professor
Tayyar Alı Mustafayev

PhD in Economics, associate professor
Kamran Nureddin Abdullayev

One-time Dissertation Council with registration number BFD 2.38/1, established on the basis of the Dissertation Council ED 2.38 operating under the Azerbaijan Technical University, under the Supreme Attestation Commission under the President of the Republic of Azerbaijan.

Chairman of the Dissertation council — Doctor of Economic Sciences, professor
Rasul Anvar Balayev

Scientific secretary of the Dissertation council — PhD in Economics, associate professor
Fargana Gazanfar Musayeva

Chairman of the scientific seminar — Doctor of Economic Sciences, professor
Alovsat Garaja Aliyev

Introduction

Relevance and level of development of the topic. In a market economy, competitiveness is the primary factor determining the sustainable activity of an economic entity. Competition is widely regarded as a pivotal catalyst for economic development, and the concept of competitiveness is recognised as a critical factor in achieving a competitive market position. Technological development in various sectors of the national economy, especially in transport, plays a pivotal role in ensuring competitiveness. In the contemporary era, characterised by the pervasive influence of digitalisation, the pivotal function of digital technologies in the realm of socio-economic development is indisputable. Intensive development in transport forms the basis for technological development in other sectors of the economy.

The digital environment has the potential to engender new realities with regard to enhancing the competitiveness of the transport sector. These realities have led to an increased focus on digital technologies in terms of revealing and implementing the possibilities of virtual development. The utilisation of digital technologies entails the immediate encoding of analogue information, predicated on the binary number system, which is then transmitted in a digital series of packets via communication channels.[1]

The utilisation of digital technologies has been demonstrated to expand the scope of implementation and dissemination of innovations, including digital ones, in terms of ensuring the competitiveness of production and overall socio-economic efficiency.

In the current century, as digitalisation processes intensify, the utilisation of innovative transport technologies gives rise to a plethora of economic, technological, social, institutional,

[1] Цифровая трансформация экономики: тенденции, поведение акторов, модели процессов. Монография / Д.Н. Верзилин, А.А. Волкова, С.А. Калайда и др. / под ред. В.В. Трофимова и С.И. Шаныгина. – СПб.: Изд-во СПбГЭУ, 2023. – с.95.

environmental and other issues. The implementation of this solution has the potential to enhance the competitiveness of transport. The advent of digital transport technologies has precipitated an escalating imperative for comprehensive research in the domain of resource conservation, the enhancement of environmental conditions conducive to the utilisation of renewable resources, the optimisation of management practices, and a plethora of other pertinent considerations. However, the scientific, theoretical and experimental problems of increasing the competitiveness of production through the use of digital transport technologies are at the initial stage of research, especially in the context of domestic scientific circulation. Consequently, emergent trends and features within a competitive environment characterised by the pervasive utilisation of digital transport technologies have received inadequate scrutiny. Moreover, the multivarious factors that determine the tangible conservation of resources within the digital environment have not been thoroughly delineated. The issue of diminishing expenses in the domains of transportation, manufacturing, and production, incorporating the costs of transactions, has not been the subject of sufficient scholarly inquiry. The role and function of analysing the dynamics of transaction costs in evaluating the efficacy of the digital sector of the economy have not been elucidated to the requisite extent.

There is a paucity of literature regarding the attitude towards the digital system of regulation of the competitive environment in the modern transport products market. Furthermore, the possibilities of increasing the efficiency of using digital transport technologies in the transport sector have been the subject of only a shred of study, and the priorities for increasing the competitiveness of transport in the context of increasing digitalization and new challenges have not been substantiated.

Conversely, the current state of the digital sector in the transport industry has not been assessed, and the emerging environment for the application of digital technologies in the transport industry has not been fully characterised. It is also important to note that the impact of modern digital technologies on

the competitiveness of transport activities is still in the early stages of research.

Azerbaijan is taking serious and systemic steps to form and develop institutional and infrastructural support for digitalization. The Decree of the President of the Republic of Azerbaijan dated January 10, 2019 on ensuring coordination in the field of innovative development in the country played a driving role in this direction. By the corresponding decree of the head of state, a public legal entity, the Center for Analysis and Coordination of the Fourth Industrial Revolution, was created.

Azerbaijan has initiated the establishment of a regulatory framework aimed at enhancing the digital environment and refining the management system for digital transformation. However, in order to facilitate the active and widespread use of digital transport technologies, it is necessary to conduct comprehensive scientific research and continue to implement measures that are substantiated in full. These measures must be implemented in order to solve institutional, economic, technological and a number of other problems.

The development of the digital economy, the use of digital technologies in transport, and aspects of innovative technologies were studied by F.S.Dashdemirov[2], R.A.Balayev[3], A.Abbasov, O.İbrahimov[4], V.M.Valiyev[5], R.K.Isgendarov[6], I.E.Ismayılov[7], A.D.Huseynova[8] and a number of other Azerbaijani scientists.

---

[2] Daşdəmirov, F.S. Avtobus dayanacaqlarında nəqliyyat axını gecikmələrinin simulyasiya sınağı// [Elektron resurs] /E3S Web of Conferences 401, 01070. – 2023. – pp.1-10. https://www.academia.edu/105815363/Simulation_testing_of_traffic_flow_delays_in_bus_stop_zone

[3] Balayev, R.Ə. İntellektual sistemlər və tenologiyalar/ R.Ə.Balayev, M.N.Əlizadə, İ.K.Musayev .– Bakı: "MSV NƏŞR". – 2016. – 256 s.

[4] Abbasov, Ə. İbrahimov, O. Rəqəmsal iqtisadiyyat: qlobal trendlər, nailiyyətlər və çağırışlar kontekstində Azərbaycanın inkişaf perspektivləri. Rəqəmsal iqtisadiyyat: Müasir çağırışlar və real imkanlar" adlı Beynəlxalq konfrans materialları. 2020. S.102-103.

[5] Vailiyev, V., Dashdamirov, F., Gurbanov, A., Ismayilova, A. Analysis of taxi service organizing and regulation for Baku city: [Electronic resource]/ Scientific

A number of scholars such as S.Sarp, M.Kuzlu[9], A.Khan, R.Thomas[10], Z.Tian, T.Zu, Z.Dong[11], Y.Kobzeva[12], C.Biyik, T.Yigitcanlar[13], S.Tanberk, M.Can[14] from abroad have conducted

---

Journal of Silesian University of Technology. *Series Transport*. – 2023, 118, – pp.229-242.

[6] Искендеров, Р.К. Формирование стратегии инновационной деятельности предприятия// - Труд и социальные отношения, – 2002. – с.77-80.

[7] İsmayılov, İ.E. Rəqəmsal iqtisadiyyat şəraitində Azərbaycanda əmək bazarının mövcud vəziyyəti və məşğulluğun təmin olunması problemləri// International conference on digital economy: Modern challenges and real opportunities, – Bakı, fevral, – 2020. – pp.1-15.

[8] Hüseynova, A.D. Qlobal iqtisadiyyatın fenomenləri və onların müxtəlif parametrlərinin müqayisəsi// Yeni Nəsil İqtisadiyyat: Çağırışlar və perspektivlər. International scientific-practical conference, 3rd forum of ECO think tanks, – Bakı, 4 oktyabr, – 2024. – pp. 19-24

[9] Sarp S., Kuzlu, M., Jovanovic, V., Polat, Z., Guler, O. Digitalization of Railway Transportation through Artificial Intelligence-Powered Services: Digital Twin Trains: [Electronic resource]/ – 2023. https://www.researchgate.net/publication/370063494_Digitalization_of_Railway_Transportation_Through_AI-Powered_Services_Digital_Twin_Trains.

[10]Iyer, L.S. AI enabled applications towards intelligent transportation: [Electronic resource]/ Transportation Engineering, 5, – 2021. 100083. https://www.sciencedirect.com/science/article/pii/S2666691X21000397

[11] Tian Z., Zhu T., Tian Z. Dong Z. Research on Key Technologies of Infrastructure Digitalization based on Multimodal Spatial Data: [Electronic resource]/ 2023. https://core.ac.uk/works/152815361/?t=undefined-152815361

[12] Khan, A., Thomas, R. The New Mobility Era: Leveraging Digital Technologies for More Equitable and Sustainable Public Transportation: [Electronic resource]/ 2024 – https://irpp.org/research-studies/leveraging-digital-technologies-for-public-transportation/

[13] Bıyık, C., Yigitcanlar, T. Intelligent Transport Systems in Turkish Urban Environments: A Comprehensive Review/ Intelligent transport systems in Turkish urban environments: a comprehensive review. International Journal of Knowledge-Based Development, – 2020. – 11(4). – pp. 382- 404.

[14] Tanberk S., Can M. Smart Journey in Istanbul: A Mobile Application in Smart Cities for Traffic Estimation by Harnessing Time Series: [Electronic resource]/ – 2022.https://www.researchgate.net/publication/366423887_Smart_Journey_in_Istanbul_A_Mobile_Application_in_Smart_Cities_for_Traffic_Estimation_by_Harnessing_Time_Series

research on various aspects of the problems associated with innovation and the application of digital technologies.

However, the aforementioned scholars did not set out to examine the role of digital and innovative transformation in the transport ecosystem.

Object and subject of research. The object of research are various sectors of the transport sector, in particular, the sector of public transport. The subject of research is the transformation of the transport ecosystem of Azerbaijan by means of digitization and innovation.

The purpose and objectives of the study. The purpose of the study and is to identify the role of digital and innovative transformation in the transport ecosystem, determine the directions and means of their implementation and impact. To achieve this goal, the following tasks have been defined:

- to characterize and assess of the features of digitalization and innovation in the transport sector;
- to analyse the current trends in the global and Azerbaijani transport systems;
- to analyse the impact of digitalization and innovation on the transport system, especially public transport;
- to assess the propensity for digitalization among different age groups in public transport in Azerbaijan;
- to analyse the digital literacy of passengers in the country's transport sector and preparation of proposals for their use;
- to justify the priorities for the formation of an innovative and digital system in the transport ecosystem.

The research methods. Such research methods as monographic, scientific abstraction, comparative analysis, synthesis, induction and deduction was used in the research.

Main provisions submitted for defense. Taking into account the scientific novelty obtained as a result of the dissertation research, the following main provisions are submitted for defense:

- In the contemporary context, effective management of the transport ecosystem through the utilisation of a digital platform has become imperative.

- The development of competitive features formed by the application of digital technologies in Azerbaijan's transport ecosystem will enhance the competitive environment and increase the efficiency of transport services.

- The younger age groups have a higher level of adoption of digital transportation services, while technological barriers and a lack of digital literacy are observed among the older population, which affects the speed and smoothness of the transition to digitalisation in the transportation sector.

- The impact of digital technologies on the competitiveness of the transport sector is a significant instrument in the resolution of economic, social and environmental issues.

- The application of digital and innovative technologies in the transportation sector is not only linked to technological advancements, but also directly related to the implementation of effective management mechanisms and coordinated strategic proposals.

- The impact of digitalisation on urban transport systems, specifically taxis and public transport, is set to be a significant contributing factor to the enhancement of service quality and the optimisation of urban mobility.

The scientific innovations of the study are as follows:

- An analysis of the management of the transport ecosystem through the digital platform was conducted.

- An evaluation was regulated the regulation of management processes within the transport ecosystem.

- The transport ecosystem is a pivotal component of sustainable development, and its interaction with the digital platform has been demonstrated to exert a significant influence on the economic, social and environmental spheres of the country.

- A study was conducted to ascertain the prevalence of digital trends among various age demographics utilising public transportation in Azerbaijan.

The theoretical and practical importance. The digital transformation of the transportation sector and the application of innovative technologies hold a priority position in Azerbaijan's

economic and social development strategies. Assessing the impact of digitalisation and innovative approaches on the efficiency of transport services, social inclusiveness, and environmental sustainability is of particular importance for improving management mechanisms in this field. The research results provide theoretical foundations and empirical examples for the implementation of digital technologies and innovations in the transportation sector, ensuring the integration of international and local best practices. These findings can be used to refine Azerbaijan's transportation policy, enhance competitiveness, and develop practical tools for sustainable urban mobility.
The findings and analyses obtained during the research process can also be used in the development of transportation development strategies, in forecasting the impact of digitalisation on the competitive environment in the country's transportation sectors, and in improving decision-making systems for the design and implementation of digital transportation technology application programs.

The research approbation. In connection with the research work, the applicant presented reports at various international and national conferences on the scientific results obtained. The applicant published seven scientific articles on this topic, one in a reputable foreign scientific journal and five in respectable Azerbaijani scientific journals.

The name of the organization where the dissertation work was completed. The dissertation was completed at the Department of Economics and Statistics of Azerbaijan Technical University.

The total volume of the dissertation in marks, indicating the volume of the structural sections of the dissertation separately. The dissertation consists of an introduction, 3 chapters, a conclusion and a list of references. The introduction is 5 pages (9770 signs), Chapter I is 29 pages (56013 signs), Chapter II is 45 pages (92271 signs), Chapter III is 60 pages (100189 signs), and the conclusion is 2 pages (5432 signs). The total volume of the research work consists of 263 612 signs.

MAIN CONTENT OF THE WORK

The dissertation's introduction is significant in establishing the relevance and advancement of the chosen topic. It delineates the object and subject, along with the research goals and objectives, the methodological approach, the scientific novelty, theoretical and practical significance of the research. Furthermore, it presents the provisions proposed for defence and provides information on the approbation, application, and structural framework of the work.

The first chapter, entitled "**Development of the transport ecosystem in the digital environmen**t", is comprised of three paragraphs. This chapter examines the scientific, theoretical and practical issues of the formation and development of the digital economy. It also analyses the impact of the environment for the application of transport technologies and digitalisation on competition in Azerbaijan. Furthermore, it explored the formation of innovative infrastructure in transport as a factor in digitalisation in the study.

The digital economy is characterised by reliance on intangible assets, mass use of information, widespread adoption of multilateral business models. Thus, the difficulty of determining the jurisdiction in which value is created. The agenda for the present moment encompasses the resolution of scientific, theoretical and practical issues pertaining to the formation and development of the digital economy. It is anticipated that this economy will assume a leading role in the realisation of the advantages of the information society. And it is in the process of formation on both a global and national scale, in terms of universal human values. It is imperative to commence this study by elucidating the notion of the digital economy. A comprehensive investigation with the motivational and structural underpinnings of its evolution is also essential. We believe that special attention should be given to digital technologies, as their role is quickly growing in shaping the digital environment, along with the key factors that affect their economic efficiency.

Comprehensive measures are being taken to establish favourable conditions for the utilisation of transport technologies in

Azerbaijan. In order to characterise the environment for the use of digital transport technologies in Azerbaijan, it is necessary to consider the state of use of network resources in the country in the existing database. In this regard, the analysis of the features of the use of the global network by enterprises, including transport enterprises, is of considerable importance. According to data from 2021 (it should be noted that since 2019, official statistics have begun to provide relatively detailed information on the use of the Internet by enterprises.

The State Program for the Development of Communication and Information Technologies in the Republic of Azerbaijan for 2010-2012 functioned to accelerate development on the basis created by the preceding program. A series of measures were implemented with the objective of attaining a novel qualitative level of development. The core objective of this process was to enhance the competitiveness of the national economy, encompassing the domain of transport.

In the rapidly evolving domain of transport, innovation and digitalisation have emerged as significant factors in enhancing efficiency, safety and the user experience. Conventional transport systems are undergoing a period of significant transformation, driven by technological advancements. This evolution is paving the way for the development of new infrastructure that supports intelligent transport systems, sustainable mobility, and digital platforms. This change is driven by increasing urbanisation, environmental concerns and the demand for improved mobility solutions. In this context, the focus will be on how innovation is changing transport infrastructure, how digitalisation affects it, and the challenges and opportunities that come with these changes.

One of the most visible impacts of digitalisation is the proliferation of Mobility as a Service (MaaS) platforms. These platforms integrate diverse modes of transportation, including buses, trains, taxis, and bicycle-sharing services, into a unified digital platform accessible via mobile applications. Examples of such applications include Uber, Bolt, and public transportation apps that allow users to plan, book, and pay for multimodal trips.

MaaS platforms have been developed to facilitate seamless travel across multiple transportation modes, thereby removing the need for passengers to purchase separate tickets or make multiple payments. The integration of such systems has been demonstrated to enhance the user experience and promote the adoption of public or shared transportation, thereby contributing to the reduction of congestion and pollution.

The application of blockchain technology has been identified as a potential solution to enhance transparency and reduce the volume of administrative tasks in domains such as freight and logistics. The blockchain technology facilitates the secure and immutable tracking of goods throughout the supply chain, thereby ensuring that all stakeholders have accurate, real-time information regarding the status of shipments. This technology has the capacity to streamline customs procedures, reduce delays, and minimise fraud, ultimately leading to more reliable and efficient transportation networks.

It is well-known that different approaches exist to innovation infrastructure. In the digital environment, however, a decrease in diversity with regard to this concept, or the emergence of unambiguously accepted approaches, has not yet been observed. A similar trend is also evident in Azerbaijan. Without comparing the above relationships, we can note that the following position is acceptable in our opinion.

In terms of supporting the competitiveness of transport, innovation infrastructure deserves attention as an investment object. Thus, the level of innovation infrastructure development plays a decisive role in the mobilisation of various resources. The relevant sources reveal that quite different approaches are adopted by the organisers of innovation infrastructure. In this regard, we consider the approach that attributes the following to the subsystems that make up innovation infrastructure to be acceptable. In the context of current production and commercial realities, it is shown here that innovation infrastructure includes the following components: production-technological, consulting, financial, personnel, information and sales.

Chapter II, entitled **"Transportation Systems Development, Global Trends, Digital Platforms and the Impact of Innovations",** consists of three paragraphs. It begins with an analysis of the global transport system. It shows that analysing the development of the transport system at local and global levels is appropriate, since it plays a slightly different role in economic development. At the international level, large-scale projects and intercontinental air or sea transport reveal the importance of developing interconnections between countries and of international cooperation. In contrast, at the local level, the focus is on improving urban and regional mobility, with major projects such as the construction and maintenance of roads being carried out. These initiatives aim to support economic development and improve quality of life.

The latest global event to have a negative impact on transport development worldwide was the large-scale Russian invasion of Ukraine. This caused serious damage to transport infrastructure. It led to major disruptions and a large influx of refugees to the EU and neighbouring countries. Various types of sanctions were imposed on Russia in response, which were intended to bring the war to a swift end, but they have proven to be ineffective.

This chapter researches the development of transport ecosystems around the world, including in CIS countries. It concludes that recent geopolitical events, particularly the consequences of Russia's invasion of Ukraine, have severely affected the global supply chain. Major shipping lanes have been closed and sea and air transport has been particularly badly affected. For instance, access to the Azov Sea has been cut off, leaving ships stranded and increasing congestion and transportation costs for companies. The transport of critical materials such as diesel fuel, grain, and rare earth metals has also been disrupted, and Ukrainian and Russian airspace has either been closed or avoided, further increasing transport costs. These disruptions pose a significant risk to industries that depend on the timely delivery of resources, such as platinum, aluminium, and electronic components. Ukrainian and Russian seafarers constitute a large proportion of the global shipping

workforce, and the current war in the region has also resulted in labour shortages. This has had a significant impact on key exports, including wheat, corn, sunflower oil and metals, leading to considerable price hikes, especially in the food and energy markets. The impact of the war has exacerbated existing supply chain stress, which was already being aggravated by the impact of the pandemic. This has made the negative impact of the war even more visible to the international community. While the pandemic has already destabilised supply chains, the additional impact of the war is expected to be long-lasting. It will affect different sectors differently depending on how long the fighting continues.

The development of a unified transport ecosystem is an important component of the CIS countries' broader goals of modernising the economy, improving regional and global connectivity, implementing sustainable practices and increasing the digitalisation of transport systems. However, the pace and scale of this transformation varies significantly depending on economic conditions, infrastructure and political context. While some countries have made progress in this area, significant financial, infrastructure and governance challenges are slowing down progress. To overcome these obstacles, the region must reduce its reliance on outdated infrastructure, modernise transport networks and improve the regulatory environment to attract foreign investment. Increasing the adoption of sustainable transport solutions and addressing cybersecurity threats are also vital for long-term development. The ability of countries to build a modern, interconnected transport ecosystem and foster broader regional cooperation will be key to their success.

Paragraph 2, entitled "**Current Trends in the World Transport System**", examines the formation of the global transport ecosystem. As countries and regions become increasingly interconnected via various trade routes, including land, air and sea corridors, an integrated approach to transport is required. Projects such as China's "One Pipe, One Road" (BRI) initiative are transforming the global transport landscape by creating infrastructure and trade networks that span continents. The BRI is a clear example

of how investing in transport infrastructure can boost economic growth and create new chances for regional cooperation, helping the global transport system as a whole. Changes to global internet policies have had a significant impact on the Pipe and Road Initiative. As with previous technological advances, the internet has transformed social, political and economic structures by decentralising communication and creating interconnected global communities. However, this expansion has deepened the digital divide, particularly between developed and developing countries. It has increased disparities in technological access and economic power and made developing countries more dependent on more developed countries. The CIS countries face a combination of infrastructural, geopolitical, financial and technological challenges when it comes to improving global transport systems. Many member countries rely on ageing Soviet-era infrastructure that has not received sufficient investment and is in urgent need of repair, which makes it difficult to maintain and modernise key transport networks.

This chapter focuses on the role of digitalisation and innovation in the transport system, analysing its advantages, challenges and risks. The digitalisation of the transport industry brings numerous benefits, such as increased efficiency, safety and sustainability, and an improved customer experience. It also creates cybersecurity risks, high costs and issues relating to workforce displacement, privacy and system reliability. However, it also creates cybersecurity risks, high costs, workforce displacement and issues regarding privacy and system reliability. As the transport industry continues to embrace digital applications, a balanced approach is needed to maximise the benefits while mitigating potential downsides. This requires thoughtful regulation, investment in cybersecurity and workforce skills development. This will enable the transport sector to harness the full potential of digital applications and create smarter, safer and more sustainable transport systems for the future.

Chapter III is titled "**Digitalisation of Global and Regional Transport Systems: The World, the CIS and the Experience of Azerbaijan**". This chapter consists of three paragraphs, each of

which has sub-paragraphs. The first paragraph is titled "**Formation of the transport ecosystem in Azerbaijan**", the second "**Digitalisation and passenger connectivity**", and the third "**The role of taxis in the world's transport ecosystem**".

Azerbaijan plays a leading role in the digitalisation of transport in the South Caucasus, particularly in the logistics sector, which is important for the country's involvement in international trade. The development of Azerbaijan's transport ecosystem is closely linked to its strategic location at the crossroads of Europe and Asia. Its role as a key transit hub for regional and international trade, particularly through initiatives such as the Trans-Caspian International Transport Route and the Pipe and Road Initiative, has attracted significant investment in the modernisation and digitalisation of its transport infrastructure. Azerbaijan serves an important function as a central transit point for both regional and international trade. Strategically located at the crossroads of Europe and Asia, it has become a critical link in global logistics, providing an alternative to traditional trade routes through Russia. This route has already been discussed in the above article in the context of analysing the situation in Kazakhstan. Since the route also goes through Azerbaijan, the country's contribution to developing a more efficient transport system is equally significant.

The relevance of applying digital technologies to the transport sector is primarily driven by the need to mitigate negative environmental impacts. The data on global CO_2 emissions from 1750 to 2022 can be seen in Figures 3.1.1. and 3.1.2. below.

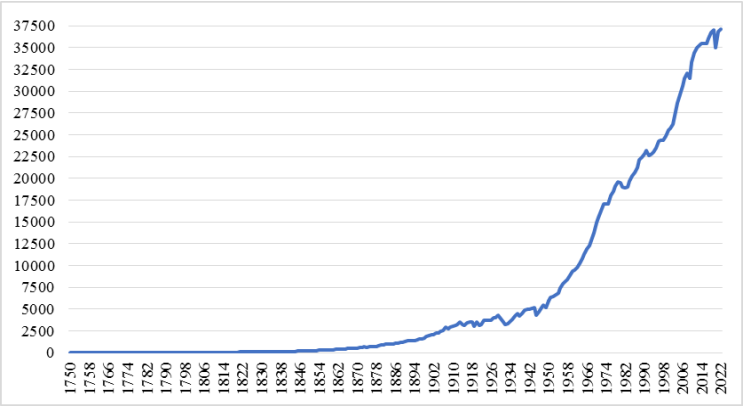


Figure 3.1.1. During 1750-2022 years annual CO2 emissons, milyon ton
Source: The author compiled it on the [15] data.

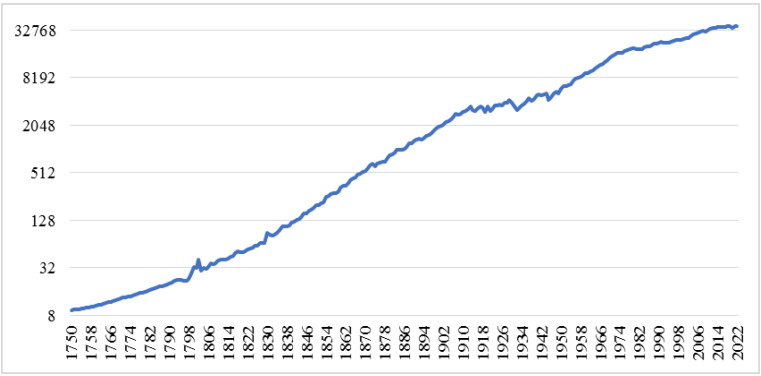


Figure 3.1.2. During 1750-2022 years annual CO_2 emissions, milyon ton (logarithmic graph)
Source: The author compiled it on the [16] data.

As Figures 3.1.1. and 3.1.2. show, the annual volume of CO_2 emissions worldwide is increasing every year along a logarithmic curve. Despite long-term policies aimed at reducing CO_2 emissions, the growth trend continues. Transport vehicles are one of the most significant contributors to the impact on the external environment,

[15] https://ourworldindata.org/
[16] Ibid

which is why technologies are being actively developed to reduce their negative impact.

Information on research conducted on topics related to digitalisation in the transport sector can be found in Table 3.1.4.

Table 3.1.4. For 2023 number of National Projects in Europe included to TRIMIS

Country	Project number	Country	Project number
Austria	7	Latvia	1
Croatia	2	Luksemburg	4
Czech Republic	5	Holland	2
Denmart	2	Poland	2
Estonia	1	Slovenia	1
Finland	1	Sweden	3
German	9	UK	3
Greece	1	Norway	1
Hungary	2	Switzerland	2

Source: The author compiled it according M.Stępniak, K.Gkoumas, F.M.D.Santos's[17] information.

As shown in Table 3.1.4, the number of digitalisation projects in the transport sector is currently low. This is primarily due to the novelty and specificity of this area. The development trends in the digital transport sector, particularly within the European context, reflect a broader trend towards reducing greenhouse gas emissions, limiting oil dependence, and enhancing the overall efficiency of transport systems while ensuring continued mobility. Innovation, particularly in terms of technological advances, infrastructure and organisational improvements, plays a central role in achieving these goals.

In the context of the development of transport systems in CIS countries, it is worth considering what trends are generally observed.

[17] Stępniak, M., Gkoumas, K., Santos, F. M. D., Grosso, M., Pekár, F. 2023. Recent trends and progress in public transport innovation in the scope of European research projects: [Electronic resource]/ Transportation Research Procedia, – 2023. – 72. – pp.4295-4302.

The following tables (3.1.5, 3.1.6, 3.1.7, 3.1.8, 3.1.9 and 3.1.10) present this information, focusing particularly on Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan and Russia.

Table 3.1.5. Freight transportation in the transport sector in some CIS countries for 2016-2023, mln.ton1

Year	2016	2017	2018	2019	2020	2021	2022	2023
Azerbaijan	222,5	226,4	230,1	235,3	188,6	193,9	218,7	229,9
Belarus	417,6	439,5	455,5	427,8	398,7	384,9	X	X
Kazakhistan	631,5	737,4	813,7	838,6	829,0	874,1	927,2	999,2
Kyrgyzstan	31,2	31,9	33,0	43,6	30,0	34,1	44,3	51,0
Russia	4 133,9	4 282,4	4 351,1	4 216,3	3 998,6	4 356,8	4 737,5	4 941,1

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic [18].

Table 3.1.6. Transport cargo turnover in some CiS countries for 2016-2023, mln. ton-km

Year	2016	2017	2018	2019	2020	2021	2022	2023
Azerbaijan	90,8	92,0	93,3	89,7	76,3	78,7	90,3	93,3
Belarus	125,8	133,3	138,8	130,8	123,2	118,8	88,6	72,9
Kazakhistan	365,1	406,7	447,2	438,4	436,2	471,4	479,7	503,5
Kyrgyzstan	2,4	2,6	2,8	2,9	2,4	2,6	2,7	2,8
Russia	5 075,6	5 367,2	5 515,1	5 554,7	5 279,2	5 627,6	5 505,1	5 465,6

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic[19].

Table 3.1.7. Passenger transportation in some CİS countries for 2016-2023, milyon passenger

Year	2016	2017	2018	2019	2020	2021	2022	2023
Azerbaijann	1 930	1 973	2 003	2 057	1 178	1 214	1 621	1 924
Belarus	1 971	1 967	1 979	1 995	1 639	1 592	1 568	1 630
Kazakhistan	1 418	1 447	1 428	1 396	874	1 118	1 486	1 607
Kyrgyzstan	682	710	732	757	422	504	527	575
Russia	18 645	18 439	18 114	17 826	12 493	13 696	14 437	15 178

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic [20].

[18] The State Statistical Committee of the Republic of Azerbaijan/ [Electronic resource]/ 2024. https://www.stat.gov.az/source/transport/?lang=en

[19] Ibid

[20] The State Statistical Committee of the Republic of Azerbaijan/ [Electronic resource]/ 2024. https://www.stat.gov.az/source/transport/?lang=en

Table 3.1.8. Transport passanger turnover in some CİS countries for 2016-2023, milyon passenger-km

Year	2016	2017	2018	2019	2020	2021	2022	2023
Azerbaijan	30,8	33,5	33,5	33,9	19,0	20,3	28,6	33,8
Belarus	24,0	24,8	25,8	27,6	18,5	20,9	21,7	23,9
Kazakhistan	49,4	51,5	55,6	60,1	33,0*	48,0*	63,5	71,3
Kyrgyzstan	11,3	12,3	12,5	13,1	7,1	9,1	10,4	11,3
Russia	519,8	560,1	593,6	635,2	357,1	492,8	508,3	564,0

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic [21].

Table 3.1.9. Total length of railway lines in operation in some CİS countries for 2016-2023, 1,000 km.

Year	2016	2017	2018	2019	2020	2021	2022	2023
Azerbaijan	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,2
Belarus	5,48	5,5	5,5	5,5	5,5	5,5	5,5	5,5
Kazakhistan	16,1	16,0	16,6	16,6	16,6	16,6	16,0	16,0
Kyrgyzstan	0,4	0,4	0,4	0,4	0,4	0,4	0,4	…
Russia	86,4	86,5	86,6	87,0	87,0	87,0	87,0	87,0

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic [22].

Table 3.1.10. Total length of railway lines in operation in some CİS countries* for 2016-2023, 1,000 km.

Year	2016	2017	2018	2019	2020	2021	2022	2023
Azerbaijan	19,0	19,0	19,2	28,5	28,6	28,7	28,3	29,5
Belarus	101,9	102,4	102,5	102,8	103,0	103,4	104,1	104,0
Kazakhistan	96,4	95,4	96,2	95,6	95,8	95,4	94,8	94,9
Russia	1498,5	1507,8	1531,5	1542,2	1553,7	1566,1	1575,6	1 579,8

Note: Although the above tables (3.1.5, 3.1.6, 3.1.7, 3.1.8, 3.1.9 and 3.1.10) present data for 5 countries, information on this indicator in the context of railway lines is not available for Kyrgyzstan.

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic [23].

This data can be used to create a single index showing the sector's development trends in each country. This index is calculated

[21] Ibid

[22] Ibid

[23] The State Statistical Committee of the Republic of Azerbaijan/ [Electronic resource]/ 2024. https://www.stat.gov.az/source/transport/?lang=en

using the geometric average of the cumulative growth rates of six selected indicators since 2016. The dynamics of this index are presented as follows:

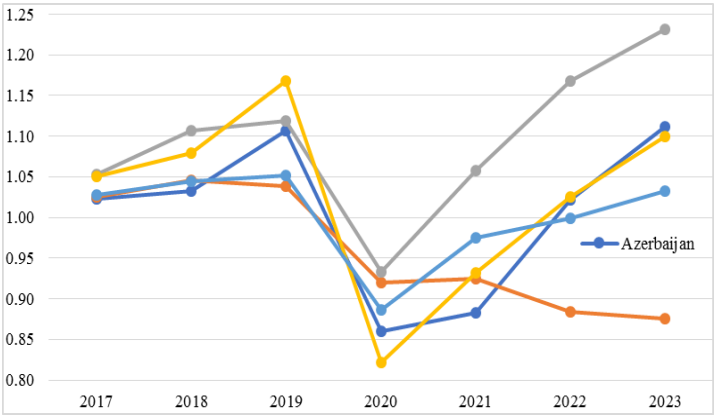


Figure 3.1.4. Logistics development index in some CIS countries in 2017-2023

Source: The author compiled it according to the informations of Statistics Commission of Azerbaijan Republic [24].

As Figure 3.1.4 shows, Kazakhstan is the country with the fastest-developing logistics (index 1.23), followed by Azerbaijan (1.11) and Kyrgyzstan (1.1). Meanwhile, the index value in Belarus has fallen below 1, indicating that the transport system's development by 2023 was lower than in 2016. While these data enable us to evaluate the state of the transport system specifically, they do not allow us to analyse it in the context of the digital transformation of transport.

Successful digital transformation and improved customer service pave the way for innovation and the development of a relevant tourism ecosystem. The main point is to understand the company's role within this ecosystem and connect with different travel services, even without owning the whole system. Partnerships and collaborations are crucial in providing companies with seamless interfaces between various ecosystem participants, enabling them to offer a door-to-door travel platform.

[24] Ibid.

Digitalisation processes are being implemented in Azerbaijan and other countries. Digitalisation has particularly become one of the priority areas for the development of Azerbaijan in the last decade. In this regard, digitalising infrastructure in the transport sector, as in other areas, is a key issue. The digitalisation trend can be influenced by many factors. One of the most important of these is age. Older people may struggle to use digital technologies. The digitalisation of transport infrastructure can create difficulties for older people when using transport. Therefore, it is necessary to study how different age groups in the population use digital transport infrastructure. A survey was conducted in Baku, the results of which are presented in the dissertation.

A survey was among 100 passengers in Baku. The survey was conducted taking into account the frequency of public transport use, the frequency of outdoor Wi-Fi use, and the frequency of online charging among passengers. We evaluated the survey results by 5 age groups: 0-20, 21-30, 31-40, 41-50, and 51-60.

Firstly, we analysed the frequency of transport use by age group. Based on this analysis, we can conclude that the age groups using transportation the most are 21-30 and 31-40, with an average monthly usage of 24 times. The age group that uses public transport the least is the 0-20 age group, with an average usage of 20 times per month. Those in the 41-50 age group use public transport an average of 23 times per month, while those in the 51-60 age group use it an average of 22 times per month.

People in the 0-20 and 21-30 age groups use outdoor Wi-Fi the most. On average, they connect to Wi-Fi outdoors 30 times per month. 51-60 age group are the least likely to use Wi-Fi outdoors. This age group uses Wi-Fi outdoors an average of 10 times per month. The average frequency of outdoor Wi-Fi usage per month is 22 for the 31-40 age group and 14 for the 41-50 age group.

A survey was conducted to determine the average frequency of outdoor Wi-Fi use per month. The main objective of this survey was to observe the impact of age, frequency of public transportation use, and frequency of outdoor Wi-Fi use on the frequency of online addictions. After analyzing the data, we came to several conclusions:

1) There is a negative correlation between age and the frequency of online deposits. For every unit increase in age, the frequency of online top-ups decreases by 0.033 units. For example, a 20-year-old passenger might make online payments four times a month, whereas a 30-year-old passenger might make three and a half times as many.

2) There is no correlation between the frequency of using public transport and making online top-ups.

3) There is a positive correlation between outdoor Wi-Fi usage frequency and online recharge. When outdoor Wi-Fi usage increases one unit, online recharge is increased by 0.04 units. For example, a person who uses outdoor Wi-Fi 10 times a month makes 2 online recharges, while a person who uses outdoor Wi-Fi 20 times a month makes 2.4 online recharges per month.

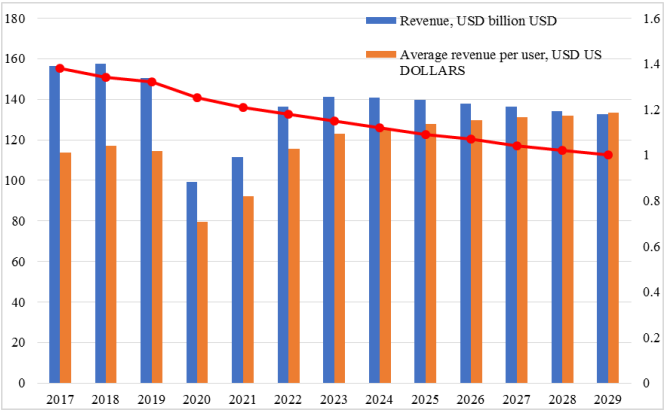
Generally, older people tend to use digital devices less. The results obtained show that the younger generation is highly integrated into digital services and widely uses technologies such as mobile applications and online payments. Interest and use of digitalisation increased among middle-aged groups, but technical barriers sometimes exist. The older population mainly prefers traditional transport services and faces restrictions when using digital services.

In general, major innovations in public transport related to digitalisation have already been implemented. These include the digitisation of road transport and the development of apps such as BlaBlaCar, Waze and Turo, which have transformed road transport. Whether you are driving or renting vehicles, the digital era has made car use more accessible and economical. Private app-based car rental services such as Uber and Gett have also become significantly more popular recently. Shared taxis such as Splitcab also optimize the efficiency of trips. As mentioned above, micromobility solutions such as bicycles and electric scooters have become significantly more common since the beginning of the COVID-19 pandemic. These modes of transport are not only more convenient from a mobility point of view in modern conditions, but also help protect the environment, as they are environmentally friendly.

It is an undeniable fact that taxis play a significant role in the global transport ecosystem, serving as a crucial component of urban mobility and offering convenience and accessibility to a wide range of users. Their role has changed significantly in recent years with the emergence of digital platforms, the development of ride-hailing services and increasing sustainability considerations. These changes have not only disrupted the traditional taxi model, but have also dynamically integrated taxis into the broader mobility ecosystem.

An assessment of current trends in the global taxi market can be made using the data shown in Figure 3.3.1.:

Figure 3.3.1. Taxi market development indicators for 2017-2029



Note: Data for 2024 are projections based on data from the Statista website[25].

Source: The author is compiled according to the Statista[26].

The situation in the context of transport development in the CIS countries can be assessed using some statistical data. It is also available in the public domain.

[25] The State Statistical Committee of the Republic of Azerbaijan/ [Electronic resource]/ 2024. https://www.stat.gov.az/source/transport/?lang=en

[26] The State Statistical Committee of the Republic of Azerbaijan/ [Electronic resource]/ 2024. https://www.stat.gov.az/source/transport/?lang=en

This dissertation analyses the digital and innovative transformation of the Azerbaijani transport ecosystem using the example of Baku city. A comparative approach is taken with international experience, and practical solutions are proposed. The primary findings indicated that the implementation of digital technologies has a substantial impact on enhancing the quality of transport services, thereby increasing user satisfaction and optimising urban mobility.

The study evaluated the evolution of the transport ecosystem within a digital environment, encompassing a comprehensive array of dimensions. It employed a comparative approach, drawing upon best international practices, and presented empirical findings from the city of Baku. The findings indicate that digital technologies exert a substantial influence on enhancing the quality of transport services, optimising urban mobility, and increasing user satisfaction.

The study established that digitalisation within the transport ecosystem encompasses not only technological transformation, but also components such as transparency of management processes, personalisation of services, and more efficient use of resources. The establishment of consolidated digital platforms for diverse transportation services has been demonstrated to enhance the interaction between public transportation and taxi services, thereby creating conditions conducive to reducing the overall transportation burden.

The primary scientific contribution of the study was the conceptual justification of the digital management model and the single platform approach in Baku. The model being examined considers the interaction between taxi and public transport services, along with the crucial role of digital platforms in a competitive environment. Furthermore, the factors affecting the quality of service and the attitude of user groups to digitalization were assessed based on empirical research. Refering to a comprehensive global experiential database and a rigorous comparative analysis with the former Soviet countries, this study systematically examined the impact of tariff policies and digitalisation on social welfare criteria.

This study was conducted with a view to examining the digital and innovative transformation of the Azerbaijani transport ecosystem. The investigation focused on the city of Baku, and the results obtained were summarised on a scientific basis. The primary objective of the present study was to ascertain the impact of digital technologies on competitiveness, service quality and urban mobility in the transport sector. In addition, the study sought to propose specific development directions in this area.

In consequence of the research, the following scientifically and practically significant results were obtained:

1. The management of the transportation ecosystem through digital platforms has become a necessity in today's world. This approach enables the improvement of service quality, the adoption of more flexible and data-driven decision-making, and the more effective satisfaction of passenger needs. In Baku, the management of taxi and public transport services through digital platforms simplifies service requests, ensures real-time data flow, and optimises resource utilisation. At the same time, digital management approaches strengthen coordination and integration among transportation services, thereby contributing to the sustainable development of urban mobility.

2. Research shows that the development of competitive features formed through the application of digital technologies in Azerbaijan's transportation ecosystem will help improve the competitive environment and increase the efficiency of transport services. The transparent rating of service quality through digital platforms, comparative monitoring of service providers' activities, and more flexible responses to user demands strengthen competition and create conditions for optimising services. This, in turn, contributes to increased passenger satisfaction, social inclusiveness, and the sustainable development of transport services. Overall, digitalisation is not only a technological innovation in the transportation sector, but also a critical tool for improving the competitive environment and enhancing service quality.

3. The findings indicate that although younger age groups have a high level of adoption of digital transport services,

technological barriers and a lack of digital literacy are observed among the older population, which hinders the speed and smoothness of the transition to digitalisation in the transportation sector.

4. Research shows that the application of digital technologies in the transportation sector not only strengthens competitiveness, but also serves as an important tool for addressing economic, social, and environmental challenges. The implementation of digital payment systems, real-time data sharing in public transport services, and the establishment of transparent rating mechanisms in taxi services contribute to greater efficiency of services from an economic perspective, increased accessibility for different user groups from a social perspective, and reduced emissions from an environmental perspective. Such digital technologies not only ensure the optimisation of resource use and enhancement of service quality in the transport sector, but also strengthen social inclusiveness and environmental protection.

5. The application of digital payment systems and route optimisation technologies in the transport sector, and the establishment of transparent pricing policies through digital platforms for both public transport under state control and private taxi services, plays an important role in management. At the same time, these technologies highlight the importance of strategic approaches not only in terms of technical advancement, but also in enhancing service quality, optimising resource use, and ensuring social inclusiveness. These findings demonstrate that when digital transformation in the transport sector is implemented alongside effective management and strategic approaches, it ensures the efficiency of services and supports sustainable development.

6. An in-depth evaluation was conducted to ascertain the impact of digitalisation on taxis and public transport vehicles. The study's findings shows that the impact of digitalisation on urban transport systems, particularly on taxi and public transportation services, significantly contributes to the improvement of service quality, increased passenger satisfaction, and more efficient management of urban mobility. For example, in Baku, digital platforms (such as Bolt, Uber, BakuBus mobile apps, etc.) allow

passengers to track the movement of transport vehicles in real time, make payments conveniently, and rate service quality. These digital solutions help to reduce traffic congestion, enable more efficient route planning, and ensure transparency in services, thereby enhancing the overall quality of the transportation sector.

The results of this study are of particular importance in terms of improving transport policy, strengthening social inclusion and adapting transport services to modern requirements in accordance with the principles of environmental sustainability. These results also contribute to balancing the economic, social and environmental dimensions of the digital transformation of the transport sector. The findings of the research indicate that digitalisation is not merely a technological development; it is also an instrumental mechanism for enhancing transparency in management and improving service quality. These findings underscore the necessity of incorporating data-driven and adaptable methodologies into urban mobility and transport planning. Moreover, the advent of digitalisation has precipitated a marked enhancement in the interaction between public transport and taxi services, thereby facilitating more efficient management of passenger flows. The digitalisation of public transport services has been identified as a key factor in facilitating social inclusion within urban areas and ensuring equal access to services. The study's findings provide a robust rationale for the implementation of policies that are designed to enhance public-private partnerships, as well as the broader utilisation of digital platforms. The study also emphasises the importance of integrating start-ups and innovation centres with the transport sector. The real-time monitoring and data analytics of smart transport systems represent a number of significant research directions for the future. The results obtained provide a substantial scientific and practical foundation for the sustainable development and competitiveness of the transport sector in Azerbaijan.

Future research should explore a range of topics, including real-time monitoring of transport flows, multimodal transport integration in smart city strategies, and the impact of digital platforms on environmental sustainability criteria. The dissertation

presents relevant and practically significant results for Azerbaijan on the role of digitalisation and innovation in the transport sector.

The main provisions and results of the dissertation are reflected in the following publications:

1. Sənayenin rəqabət qabiliyyətinin təmin edilməsində informasiya resurslarının yeri və rolu// İqtisadiyyat İnstitutunun elmi əsərləri. № 3. - Bakı. - 2018. - s. 155-160.
2. İndikator funksiyası və transaksiya xərclərinin kəmiyyətcə ölçülməsi// 16-17 dekabr 2021-ci il tarixlərində Sumqayıt Dövlət Universiteti və Yıldız Texniki Universitetinin birgə təşkilatçılığı ilə keçirililmiş "İnformasiya cəmiyyətində iqtisadiyyatın davamlı inkişaf problemləri" mövzusunda Beynəlxalq elmi konfransın materialları. - Sumqayıt. - 2021. № 10. – s. 395-399.
3. Rəqəmsal iqtisadiyyat şəraitində transaksiya xərclərinin rolu// Azərbaycan Respublikası Təhsil Nazirliyi Azərbaycan Respublikası Rəqəmsal İnkişaf və Nəqliyyat Nazirliyi Azərbaycan Texniki Universiteti Həştərxan Dövlət Texniki Universiteti "Təhlükəsiz infotelekommunikasiya sistemləri: nəzəriyyədən tətbiqə" mövzusunda Beynəlxalq elmi-praktiki konfransın materialları. - Bakı. - 2021. - s. 37-43
4. Rəqəmsal iqtisadi-texnoloji mühitdə sənayə istehsalının rəqabət qabiliyyətinin yüksəldilməsi istiqamətləri// Kooperasiya elmi praktiki jurnal. - №4 (63). - Bakı. - 2021. - s.112-120.
5. Sənaye məhsulları bazarında rəqabət mühitinin dövlət tənzimlənməsinin rəqəmsal sisteminin formalaşdırılması// The XXIII International Scientific Symposium "Integration of cultures and multiculturalism", dedicated to the 305 anniversary of Molla Panah Vagif International Scientific Symposium. Qars-Bakı. - 2022. - №17. - s.207-209.
6. Концептуальные вопросы формирования цифровой экономической среды и повышения конкурентоспособности// Вестник Алтайской Академии

Экономики и Права. Алтайский Край. № 2. - 2022. - с.147-154.
7. Digital economy development and its impact on the economy: literature review// International scientific-practical conference "The world of scientific research". - Poland. – 2022. - Issue 7. - pp.8-11.
8. Rəqəmsal mühitdə transaksiya xərclərinin ölçülməsinin metodiki aspektləri// Azərbaycan Texnologiya Universiteti. UTECA. İnnovasiyalı iqtisadiyyat və menecment. - Gəncə. - 2022. - №3. - s.88-94.
9. Rəqəmsal sənaye texnologiyalarının tətbiqinin səmərəliliyinin yüksəldilməsi// Tikinti iqtisadiyyatı və menecment. - Elmi praktik jurnal. - Bakı. - 2022. - № 3. - s.188-197.
10. Measuring the Tendency of the Age Groups of the Population to the Digitalization of the Transport Infrastructure in Azerbaijan// 2nd international scientific-practical conference machine building and energy: new concepts and technologies (MBENCT). Trans Tech Publications Ltd. - Switzerland. - 2024. - Issue. - pp.508-513.
11. Digitalization of transportation infrastructure in Azerbaijan: issues and trends// İqtisadi Artım və İctimai Rifah. - 2024. - № 2. - pp.109-113.

E. Vüqarlı

The defense will be held on "28" October 2025 at 14^{00} at the meeting of the One-time Dissertation Council with registration number BFD 2.38/1, established on the basis of the Dissertation Council ED 2.38 operating under the Azerbaijan Technical University.

Address: 25 H. Javid Avenue, Baku, Azerbaijan AZ 1073

Dissertation is accessible at the Library of the Azerbaijan Technical University.

Electronic versions of dissertation and its abstract are available on the official website of the Azerbaijan Technical University (www.aztu.edu.az).

Abstract was sent to the required addresses on "26" September 2025.

Signed for print:24.09.2025
Paper format: A5
Volume: 36320
Number of hard copies: 20