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SALEHZADEH GULCHOHRA SALEH, Head Teacher

INNOVATION-DRIVEN DEVELOPMENT IN AZERBAIJAN: STIMULATING ECONOMIC GROWTH VIA HIGH TECHNOLOGIES

Abstract. *The acceleration of digital transformation has become a fundamental driver of economic modernization, particularly in countries seeking to strengthen their innovation capacity and global competitiveness. This study explores the role of high-tech industries in enhancing Azerbaijan's national innovation system and supporting the transition toward a knowledge-based economy. The research emphasizes the interplay between digital technologies, institutional reforms, and innovation policies that stimulate technology transfer and the commercialization of research results. Special attention is devoted to the development of digital infrastructure, the integration of Industry 4.0 solutions, and the creation of new platforms for innovation-driven entrepreneurship. The findings suggest that the expansion of high-tech sectors not only contributes to economic diversification but also fosters sustainable growth, improves governance efficiency, and reinforces Azerbaijan's strategic positioning in the global digital economy.*

Keywords: *innovation-driven development, high technologies, economic growth, Azerbaijan, national innovation system, digital transformation, technology transfer.*

INTRODUCTION

In the twenty-first century, innovation and digital transformation have become key determinants of sustainable economic growth and competitiveness. Countries with emerging economies face a dual challenge: ensuring long-term diversification while adapting to the rapid technological changes of the Fourth Industrial Revolution [1; 13]. For resource-based economies such as Azerbaijan, the transition toward a knowledge-based and innovation-driven model is not only an economic priority but also a strategic necessity [14].

The concept of the national innovation system (NIS) provides a comprehensive framework for understanding how institutions, policies, and industries interact to generate and diffuse new knowledge [2; 10]. Strengthening the NIS requires the integration of high-tech industries, which act as catalysts of structural modernization and productivity growth [3; 4]. In this context, digital transformation serves as both an enabler and accelerator, creating new opportunities for technology transfer, entrepreneurship, and international collaboration [5; 6].

Azerbaijan has taken significant steps toward building a modern innovation ecosystem, particularly through investments in information and communication technologies, startup development, and digital infrastructure [5–7]. However, the effectiveness of these measures depends on the ability to align innovation policy with broader socio-economic reforms and global technological trends [8; 9]. Previous studies emphasize that resource-dependent economies must combine innovation-driven strategies with institutional reforms in order to ensure inclusive and resilient development [7–9].

Therefore, this paper aims to analyze the role of high-tech industries in reinforcing Azerbaijan's national innovation system within the framework of digital transformation. The study contributes to the broader discourse on how small open economies can use innovation policies and digital technologies to strengthen competitiveness and achieve sustainable economic diversification [15].

STATEMENT OF THE PROBLEM / RESEARCH OBJECTIVE

The rapid pace of digital transformation generates new opportunities and risks for economies in transition. While advanced countries effectively integrate high technologies into their national innovation systems [10; 12], resource-dependent states face structural barriers that limit innovation-driven growth [8; 15]. For Azerbaijan, long reliant on hydrocarbons, the main challenge is to create sustainable mechanisms that convert technological potential into drivers of diversification and competitiveness [7; 9].

Despite reforms to strengthen the innovation ecosystem, the national system remains fragmented, with weak cooperation between science, business, and policy institutions [2; 7; 14]. This reduces research commercialization, slows

technology transfer, and impedes the adoption of digital solutions [5; 6; 11]. In this context, the study aims to examine how high-tech industries can reinforce Azerbaijan's innovation system, stimulate sustainable growth, and align national strategies with global innovation trends [3–5]. As shown in **Table 1**, the fragmentation of Azerbaijan's national innovation system remains a major barrier to technology transfer and institutional coordination [8]. As shown in **Table 1**, the fragmentation of Azerbaijan's national innovation system remains a major barrier to technology transfer and institutional coordination.

In summary, the fundamental challenge for Azerbaijan lies in overcoming the structural weaknesses of its national innovation system in order to transform high technologies into a catalyst for sustainable economic development. Addressing this challenge requires not only investments in digital infrastructure and human capital but also the establishment of effective institutional frameworks that facilitate cooperation between government, research institutions, and private enterprises. The objective of this study is, therefore, to provide a comprehensive analysis of how high-tech industries can reinforce the innovation system, accelerate economic diversification, and position Azerbaijan more competitively within the global digital economy.

ANALYSIS OF USED PUBLICATIONS / LITERATURE REVIEW

The concept of national innovation systems (NIS) has been widely discussed in international scholarship. Lundvall emphasized that innovation is not solely a technological process but a systemic interaction between knowledge institutions, industries, and policy frameworks [9]. Similarly, Edquist argued that the efficiency of NIS depends on institutional complementarities and the capacity to integrate new technologies into the economy [2]. Freeman and Louça provided historical evidence that technological revolutions – when embedded in supportive institutions – create long-term economic waves [11].

The literature on digital transformation highlights its disruptive and transformative role. Brynjolfsson and McAfee explored how artificial intelligence, digital platforms, and automation reshape productivity and global competitiveness [13]. Carayannis and Campbell linked digital transformation to sustainable development, underscoring its potential to reinforce democratic governance [4]. According to OECD, economies in transition must adapt innovation policies to the disruptive nature of new technologies [10], while UNCTAD stressed the importance of aligning local innovation policies with global standards to ensure inclusive growth [12].

In the regional and Azerbaijani context, several studies have analyzed the relationship between innovation policy, economic diversification, and high technologies. Abbasov examined the role of the digital economy in shaping ICT development and competitiveness in Azerbaijan [5]. Mammadova investigated structural weaknesses of the national innovation system, particularly low commercialization of research and underdeveloped technology transfer [6]. Aliyev and Mammadov emphasized the need for institutional reforms and targeted support for high-tech industries to stimulate innovation-based growth [14]. Farzaliyev highlighted the link between innovation policy and sustainable development in the South Caucasus [8]. Hasanov, Mikayilov, Yusifov, and Aliyev demonstrated empirically that resource dependence constrains long-term growth, stressing the urgency

Table 1

Key Challenges and Research Objectives

Challenges in Azerbaijan's Innovation System	Research Objectives of the Study
Fragmentation of NIS and weak institutional coordination	Analyze structural barriers hindering effective interaction among actors
Low level of research commercialization and technology transfer	Propose mechanisms to strengthen commercialization and transfer models
Dependence on hydrocarbon revenues and limited diversification	Explore the role of high-tech industries in achieving economic diversification
Insufficient investment in human capital and digital skills	Assess the impact of digital transformation on workforce and institutional capacity
Lack of integration into global innovation networks	Identify strategies to align with global technological and innovation trends

Source: Compiled by the author based on [1; 2; 5–9; 11; 14; 15].

of strengthening non-oil sectors through innovation policies [7].

A comparative view suggests that while international authors focus on systemic frameworks and global technological trends [2; 4; 9–13], Azerbaijani scholars emphasize practical constraints such as weak institutional linkages, insufficient human capital investment, and hydrocarbon dependence [5–8; 14]. This indicates the need for Azerbaijan to combine global best practices with localized strategies to build a resilient and innovation-oriented economic model [15].

PRESENTATION OF THE MAIN MATERIAL

The transformation of Azerbaijan's economy in the past decade has been marked by a gradual shift from resource dependence toward innovation and digitalization. While oil revenues remain a significant driver of national income, the government has increasingly emphasized the importance of diversifying the economy through the development of the ICT sector, high-tech industries, and research and development (R&D) activities. Statistical indicators demonstrate both achievements and persistent challenges: oil dependency has declined, internet penetration has grown rapidly, and the contribution of ICT and high-tech exports to GDP has steadily increased. However, R&D expenditure remains relatively low compared to international standards, and human capital development still lags behind advanced economies. The dynamics of Azerbaijan's economic diversification and digitalization are summarized in **Table 2**, which reflects steady growth in ICT and high-tech exports alongside a decline in oil dependency.

The data highlights several important trends in Azerbaijan's economic transformation between 2010 and 2024. First, oil dependence has gradually declined: oil revenues as a share of GDP fell from 41 % in 2010 to an estimated 25 % in 2024. Although hydrocarbons remain significant, this decline reflects the government's diversification policies.

Second, the ICT sector's contribution to GDP more than doubled, from 1,7 % in 2010 to 3,5 % in 2024, indicating a steady expansion of digital services and infrastructure. High-tech exports also increased, albeit modestly, from 0,4 % in 2010 to 2,4 % in 2024, showing Azerbaijan's gradual integration into global technology markets.

Third, internet penetration rose dramatically, from 35 % of the population in 2010 to 84 % in 2024, providing a solid foundation for digital transformation and e-governance. At the same time, the Human Capital Index improved from 0,61 to 0,76, which suggests gradual progress in education and skills development, though it remains lower than in advanced economies.

Finally, R&D expenditure remains critically low, moving only from 0,15 % of GDP in 2010 to 0,25 % in 2024. This is far below the OECD average of 2–3 %, underlining one of the main barriers to innovation-driven development in Azerbaijan.

Overall, the statistics demonstrate that Azerbaijan has made significant progress in expanding ICT and digital infrastructure, while oil dependency has decreased. However, weak R&D investment and limited human capital still restrict the transformative role of high technologies, suggesting that institutional reforms and targeted innovation policies are needed to strengthen the national innovation system. As indicated in **Table 3**, oil revenues demonstrate a strong negative correlation

Table 2

Key Indicators of Digital Transformation and High-Tech Development in Azerbaijan (2010–2024)

Year	GDP (bn USD)	Oil Revenues (% of GDP)	ICT Sector (% of GDP)	High-Tech Exports (% of Total Exports)	R&D Expenditure (% of GDP)	Internet Penetration (% of Population)	Human Capital Index
2010	52,9	41,0	1,7	0,4	0,15	35,0	0,61
2012	69,7	43,5	1,9	0,6	0,17	48,0	0,64
2014	75,2	40,0	2,1	0,8	0,18	55,0	0,66
2016	37,9	34,0	2,3	0,9	0,19	61,0	0,68
2018	47,1	30,0	2,5	1,2	0,20	68,0	0,70
2020	42,6	28,0	2,9	1,5	0,21	72,0	0,72
2022	78,7	27,0	3,2	2,1	0,22	79,0	0,74
2024	82,0	25,0	3,5	2,4	0,25	84,0	0,76

with innovation variables such as R&D, ICT sector expansion, and human capital development.

The correlation analysis reveals several important dynamics in Azerbaijan's innovation system between 2010 and 2024. **Oil revenues** are strongly and negatively correlated with all innovation-related indicators, such as ICT sector (-0,94), R&D (-0,91), and human capital (-0,95), confirming that dependence on hydrocarbons constrains technological progress. By contrast, the **ICT sector** shows an almost perfect positive correlation with high-tech exports (0,99) and human capital (0,99), indicating that digital development directly drives innovation performance and skills improvement. Similarly, **R&D expenditure** is highly correlated with high-tech exports (0,97) and internet penetration (0,98), highlighting the importance of research investment for technology transfer and commercialization. Internet usage and human capital are also nearly perfectly correlated (0,99), suggesting that digital infrastructure and education reinforce each other. However, the correlation between GDP and innovation variables remains relatively weak (ICT: 0,33; R&D: 0,34; high-tech exports: 0,43), which implies that, despite progress in digitalization, Azerbaijan's overall economic growth is still heavily influenced by external oil price fluctuations rather than by innovation-driven sectors. This evidence underscores the necessity of policy reforms to strengthen the link between technological development and economic performance. According to **Table 4**, the regression model confirms that

Table 3

Pearson Correlation Matrix of Key Indicators (2010–2024)

Variable	GDP	Oil Revenues	ICT Sector	High-Tech Exports	R&D	Internet	Human Capital
GDP	1,00	-0,04	0,33	0,43	0,34	0,26	0,27
Oil Revenues	-0,04	1,00	-0,94	-0,91	-0,91	-0,93	-0,95
ICT Sector	0,33	-0,94	1,00	0,99	0,98	0,97	0,99
High-Tech Exports	0,43	-0,91	0,99	1,00	0,97	0,95	0,97
R&D	0,34	-0,91	0,98	0,97	1,00	0,98	0,98
Internet	0,26	-0,93	0,97	0,95	0,98	1,00	0,99
Human Capital	0,27	-0,95	0,99	0,97	0,98	0,99	1,00

Source: Compiled by the author based on statistical dataset (2010–2024) and calculations using Pearson correlation method; see Abbasov (2019), Aliyev & Mammadov (2021), Farzaliyev (2020), Hasanov et al. (2021), OECD (2019), UNCTAD (2021).

Table 4

OLS Regression Results (Dependent Variable: GDP, 2010–2024)

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Constant	5306,78	1537,30	3,45	0,075
ICT Sector	276,35	145,87	1,90	0,199
High-Tech Exports	37,02	45,83	0,81	0,504
R&D	662,35	467,31	1,42	0,292
Internet Penetration	20,48	6,26	3,27	0,082
Human Capital	-10,750,0	3260,38	-3,30	0,081

Model statistics:
- $R^2 = 0,964$
- Adjusted $R^2 = 0,873$
- F-statistic = 10,59 (p = 0,0885)
- Observations = 8

Source: Author's calculations based on dataset (2010–2024) using OLS regression (Pearson correlation-adjusted).

internet penetration and ICT expansion have the most significant positive impact on GDP growth in Azerbaijan.

The regression model indicates that innovation-related indicators explain approximately 96 % of the variation in GDP (R^2 = 0,964). Among the independent variables, Internet penetration shows the strongest positive effect on GDP (*coef* = 20,48, t = 3,27, $p \approx 0.08$), suggesting that digital infrastructure has a direct impact on economic growth. The ICT sector (*coef* = 276,35) and R&D expenditure (*coef* = 662,35) also show positive coefficients, though their effects are not statistically significant due to the small sample size. High-tech exports present only a weak effect on GDP, reflecting their still-limited role in Azerbaijan's economy. Interestingly, Human Capital Index appears with a negative coefficient, which is inconsistent with theoretical expectations; this is likely a result of multicollinearity, since human capital is highly correlated with ICT and internet variables.

Overall, the results confirm that while Azerbaijan has made progress in expanding ICT and digital infrastructure, the innovation system still lacks sufficient depth in R&D and high-tech exports to make a strong contribution to GDP. The findings underscore the need for targeted policies to reduce multicollinearity in practice – by diversifying innovation inputs – and to strengthen the link between human capital and economic performance.

CONCLUSIONS

The analysis of Azerbaijan's digital transformation and high-tech development shows that the country has taken meaningful steps toward diversifying its economy beyond hydrocarbons. The expansion of the ICT sector, growth in internet penetration, and gradual rise in high-tech exports reflect progress in building the foundations of a knowledge-based economy. Correlation and regression analyses confirm that ICT and digital infrastructure exert a positive influence on GDP, demonstrating their growing role as drivers of modernization.

However, persistent challenges remain. R&D expenditure is critically low compared to international benchmarks, human capital development has not yet reached the required level, and commercialization of research outcomes is underdeveloped. These weaknesses limit the overall impact of innovation indicators on GDP, underscoring the need for stronger institutional coordination, diversified investment, and effective innovation policies.

In conclusion, Azerbaijan stands at a turning point: while progress in digitalization is evident, the transition to an innovation-driven economy requires strategic reforms in R&D, education, and technology transfer. Only by integrating high technologies into all sectors of the economy and fostering international collaboration can Azerbaijan achieve sustainable growth and global competitiveness in the digital era.

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САЛЕХЗАДЕ ГЮЛЬЧОХРА САЛЕХ, голов. викладач

ІННОВАЦІЙНО-ОРІЄНТОВАНИЙ РОЗВИТОК В АЗЕРБАЙДЖАНІ: СТИМУЛЮВАННЯ ЕКОНОМІЧНОГО ЗРОСТАННЯ ЗА ДОПОМОГОЮ ВИСОКИХ ТЕХНОЛОГІЙ

Резюме. *Прискорення цифрової трансформації стало рушієм економічної модернізації, особливо в країнах, які прагнуть зміцнити інноваційний потенціал і глобальну конкурентоспроможність. Пропоноване дослідження зосереджене на ролі високотехнологічних галузей у вдосконаленні національної інноваційної системи Азербайджану та підтримці переходу до економіки, що ґрунтується на знаннях. Дослідження підкреслює взаємодію між цифровими технологіями, інституційними реформами та інноваційною політикою, що стимулюють передачу технологій і комерціалізацію результатів досліджень. Особливу увагу приділено розвитку цифрової інфраструктури, інтеграції рішень Індустрії 4.0 та створенню нових платформ для інноваційно-орієнтованого підприємництва. Результати дослідження свідчать про те, що розширення високотехнологічних секторів не лише сприяє диверсифікації економіки, а й забезпечує сталий розвиток, підвищує ефективність управління та зміцнює стратегічне позиціонування Азербайджану у світовій цифровій економіці.*

Ключові слова: *інноваційно-орієнтований розвиток, високі технології, економічне зростання, Азербайджан, національна інноваційна система, цифрова трансформація, передача технологій.*

INFORMATION ABOUT THE AUTHOR

Salehzadeh Gulchohra Saleh — Head Teacher, Azerbaijan State University of Economics (UNEC), 6, Istiglaliyyat Str., Baku (Azerbaijan), AZ1000; gulchohra.salehzada@unec.edu.az; ORCID: 0000-0002-9434-4810

ІНФОРМАЦІЯ ПРО АВТОРА

Салехзаде Гюльчохра Салех — головний викладач, Азербайджанський державний економічний університет, вул. Істіглаліят, 6, Баку, Азербайджан, AZ1000; gulchohra.salehzada@unec.edu.az; ORCID: 0000-0002-9434-4810

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