Innovation as a Catalyst for Transport Sector Development: Evidence from Azerbaijan

Aliagha Gasimov[1[0000-0001-7326-112X]], Sevar Mammadova[2[0000-0002-7565-6093]], Elman Ibishov[3[0000-0003-4450-561X]]

[1] Azerbaijan State University of Economics, Istiglaliyyat str., 6 AZ1001, Baku, Azerbaijan
aliaqa.qasimov@unec.edu.az
[2] Azerbaijan State University of Economics, Istiglaliyyat str., 6 AZ1001, Baku, Azerbaijan
sevar_mammadova@unec.edu.az
[3] Azerbaijan State University of Economics, Istiglaliyyat str., 6 AZ1001, Baku, Azerbaijan
elman_ibishov@unec.edu.az

Abstract. The main objective of this study is to provide an econometric assessment of the impact of innovations on the development of the transport sector in the Republic of Azerbaijan. To this end, theoretical approaches regarding the influence of innovations on the transport sector have been examined. The literature review reveals that innovations contribute positively to the development of the transport sector through various channels, including increased efficiency in freight transportation, reduction of operational costs, and mitigation of environmental problems. The transport sector plays a significant role in both the global and national economy by exerting direct and indirect effects. In recent years, the increased attention of the state to this sector has stimulated its development.
In order to determine the impact of innovations on the development of the transport sector in Azerbaijan, two estimations were conducted using the FMOLS method. Due to the lack of sufficient statistical data on innovations, research and development (R&D) expenditures—representing the creation and advancement of innovations—were used as a proxy variable. The indicators employed in the econometric models cover the period 2005–2024 and were obtained from the database of the State Statistical Committee of Azerbaijan. The econometric results indicate that, in the long run, R&D expenditure will have a positive effect on profit growth and value added in the transport sector. Although there has been a substantial increase in R&D expenditures in Azerbaijan over the years, a comparative analysis with other countries reveals existing shortcomings. It is believed that the implementation of appropriate measures in this direction can further enhance R&D expenditure in the country. The necessary diagnostic tests conducted for the applied econometric models confirm their adequacy.

Keywords: Transport Sector, İnnovations, Research and Development (R&D) Expenditures, Econometric Models, Fully Modified Ordinary Least Squares (FMOLS) Method

1 Introduction

In contemporary paradigms of economic development, innovation is regarded as a key determinant of productivity, competitiveness, and structural transformation. The transport sector is a critical infrastructure component that operates continuously to ensure a country's economic development dynamics, international integration, and social welfare. Therefore, equipping transport systems with technological advancements, digital transformation, and innovative management methods enhances the sector's flexibility, reliability, and sustainability. In this context, innovation encompasses not only investments in physical infrastructure but also multidimensional approaches such as the application of information and communication technologies, optimization of logistics chains, and modernization of quality control mechanisms.
Azerbaijan's strategic geographical location positions it as one of the key transit countries connecting Europe and Asia in the field of transport and logistics. This role necessitates the implementation of large-scale infrastructure projects aligned with the requirements of the 21st century, including international transport corridors, modern logistics centers, and intelligent transport systems. Among the priority areas of state policy, the digitalization of the transport sector, the adoption of innovative technologies, and the enhancement of institutional flexibility occupy a central place, serving as key drivers of sectoral development. For instance, Azerbaijan improved its position in the 2023 Global Innovation Index (GII), ranking 89th among 132 countries. This progress indicates certain advancements in innovation inputs and outputs.
The primary objective of this study is to systematically and empirically assess the impact of innovations on the development of Azerbaijan's transport sector. Within the framework of the research, the effects of implementing innovative technologies on the quality of transport services, economic efficiency, international competitiveness, and sustainable development have been analyzed using scientific and analytical methods. Thus, this study holds both theoretical and practical significance, as it not only identifies how innovation-driven development enhances the efficiency of the transport sector but also reveals its potential contribution to the country's economic reforms and competitive international position.

2 Problem statement

Based on the findings of studies conducted worldwide, the impact of innovations on transportation can be examined from several perspectives. It should be noted that the growth of freight transportation and turnover is considered one of the key indicators of the transport and logistics sectors in the global economy. Innovations such as digital technologies, information and communication systems, automation, and intelligent transport infrastructures serve as critical drivers that enhance productivity and competitiveness in the transportation sector [1]. The integration of technological changes into freight transport systems also plays a direct role in increasing cargo volume and transport turnover through the restructuring and reorganization of logistics processes.
It can be emphasized that the impact of innovation on freight transportation manifests itself in several directions:
- improving operational performance and productivity.

- enabling data-driven decision-making and planning.
- increasing network efficiency.
- optimizing demand–supply coordination.

All these mechanisms collectively facilitate faster, more cost-effective, and more reliable transportation of goods.

The widespread application of IoT sensors enables continuous monitoring of the condition of vehicles, roads, and other infrastructure elements. When these data are analyzed by logistics and transport management centers, preventive measures can be taken to avoid delays, accidents, and suboptimal conditions. Such a proactive management approach reduces operational costs while improving the overall performance of transport systems [2,3].

The adoption of innovative technologies makes a significant contribution to reducing operational costs in the transportation sector, thereby enabling more cost-efficient freight and passenger transport. Autonomous driving systems reduce human error and optimize driving behavior, lowering fuel consumption and operational time. Frequent sudden maneuvers, irregular speed changes, and suboptimal route selection lead to fuel and time losses, whereas autonomous systems implement more stable and efficient control strategies to minimize these inefficiencies [4,5].

The deployment of autonomous and connected vehicles can substantially improve safety levels in transport systems, as these technologies rely on algorithmic and sensor-based decision-making mechanisms to reduce human error. In traditional driving, a large proportion of road accidents result from human mistakes, inattention, and delayed decision-making. In contrast, autonomous systems integrate real-time data from radar, LiDAR, cameras, and other high-precision sensors to generate automatic responses, thereby reducing accident risks [6].

Digitalization and Intelligent Transport Systems (ITS) enable the real-time use of accurate data in the planning and execution of logistics processes. Such approaches optimize load factors, reduce empty return trips, and thus allow more goods to be transported within shorter timeframes. Optimization and simulation techniques, as well as artificial intelligence and machine learning methods, enhance operational efficiency and overall system performance in freight transport [1].

In modern transport systems, sensor convergence (radar + LiDAR + video) ensures accurate object detection and movement prediction. These technologies not only monitor the environment but also integrate with in-vehicle artificial intelligence models to identify potential risks in advance and trigger automated response mechanisms. This approach significantly reduces accident probability, particularly in interactions with pedestrians, cyclists, and other road users, thereby improving overall system safety [6].

On the other hand, freight transport management based on artificial intelligence and data analytics not only increases operational efficiency but also improves demand forecasting. For example, the use of AI and econometric methods enhances the accuracy of freight pricing and demand forecasting, thereby increasing planning flexibility and contributing to turnover growth [7].

AI-based algorithms, particularly in route optimization and load distribution, enable drivers and transport companies to make more accurate decisions under real-time conditions. These systems can predict traffic congestion, road blockages, and accident risks, and identify alternative routes, thus improving transport performance and time efficiency. In particular, the integration of large-scale IoT data with AI facilitates more adaptive and flexible transport system management [2].

Furthermore, smart road infrastructure and vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication systems play a crucial role in enhancing transport safety. These systems ensure continuous data exchange between roads, signaling systems, and transport management centers, providing early warnings about delays, roadworks, and critical intersections. The combination of reactive and proactive safety mechanisms helps prevent accidents and provides high-precision situation awareness to both drivers and management systems [8].

Blockchain and related technologies ensure secure, transparent, and rapid data sharing within the logistics chain, reducing delays and costs in the management of freight documentation. As a result, logistics service providers can carry out faster international transit operations, which positively affects overall turnover growth.

All these technological applications enable companies to utilize their resources more efficiently. Through intelligent planning algorithms, vehicle capacity, route selection, and intermodal transport are optimized, allowing more goods to be transported with the same resources. This leads to higher capacity utilization rates and ultimately increased turnover.

Another perspective suggests that new technologies significantly enhance the operational performance of transport systems, with artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and other digital tools at the core of this improvement. These technologies provide real-time traffic monitoring, dynamic resource allocation, and automated decision support for anticipated disruptions, thereby increasing operational efficiency and reducing congestion [2].

In practice, the use of AI results in more efficient route selection and reduced loading and unloading times, which lowers operational costs while increasing freight volume [9]. This approach also enhances the adaptability of global supply chains, as companies can adjust to varying infrastructure conditions.

When such technologies are integrated with connected transport infrastructures and smart management platforms, resource coordination within the system becomes more efficient. For instance, freight planning and interdepartmental logistics modules monitor performance indicators automatically, optimize resource allocation, improve scheduling, and reduce idle time for both personnel and equipment. Consequently, third-party service costs, delay penalties, and unplanned expenditures are significantly reduced [4].

Innovations also accelerate demand elasticity and market expansion within the supply chain. Digital platforms and IoT systems improve the visibility of logistics networks, enhancing service levels across different markets. This process encourages companies to enter new markets and ultimately contributes to overall turnover growth.

The impact of Industry 4.0 technologies is significant at both practical and operational levels. Big data analytics help identify and learn dynamic traffic patterns, enabling transport management systems to adjust their behavior in real time. This approach leads to reduced CO_2 emissions, minimized fuel consumption, and improved energy efficiency, thereby playing a crucial role in enhancing the sustainability of transportation systems [2].

In conclusion, it is evident from all the above perspectives that innovations have a positive and multidimensional impact on the development of the transportation sector.

3 Main body

3.1 The Transport Sector in the Global Economy

The transport sector, as a structural component of the economic system, connects the stages of production, distribution, and consumption. Empirical studies indicate a strong positive correlation between transport infrastructure and economic growth. For instance, research conducted by the World Bank shows that a 10% reduction in transport costs can increase the volume of international trade by up to 20% on average [10].

The impact of infrastructure investments on economic growth has also been statistically confirmed. According to analyses conducted across OECD countries, the long-term elasticity of GDP growth with respect to transport infrastructure investment is estimated within the range of 0.05–0.15 [11]. This implies that investments in the transport sector are a crucial factor in ensuring sustainable economic growth.

The share of the transport sector in GDP varies depending on countries' levels of development and economic structures. According to data from the Bureau of Transportation Statistics, transportation and logistics services accounted for 6.3% of GDP in the United States in 2024 [12]. Based on Eurostat data, the share of the transport and storage sector in the European Union's GDP is approximately 5% [13]. According to reports by the International Transport Forum, this figure ranges between 8–12% in some developing countries [14].

At the global level, the economic weight of the transport sector is even broader. According to estimates by the World Economic Forum, the combined share of transport and logistics in global GDP is approximately 10–12% [15].

Moreover, when the indirect effects of the transport sector are considered, its economic significance becomes even greater. For example, logistics costs account for approximately 10–15% of global GDP on average [16].

The transport sector serves as the backbone of international trade infrastructure. Statistical data indicate that approximately 80–90% of global trade by volume is carried out via maritime transport [17], while air transport accounts for more than 35% of global trade by value [18].

Transport costs have a direct impact on the volume of international trade. Empirical models demonstrate that reductions in transport costs significantly increase trade flows within the framework of the gravity model of trade [19].

At the same time, containerization has led to revolutionary changes in global trade. Marc Levinson notes that the adoption of container shipping dramatically reduced transport costs and accelerated the expansion of global trade [20].

The transport sector also plays a significant role in the labor market. According to statistical indicators, approximately 10 million people are employed in the transport sector in the European Union [13], while employment in transportation and logistics in the United States exceeds 14 million [12]. At the global level, the sector's direct and indirect impact on employment encompasses hundreds of millions of people [21]. A distinctive feature of this sector is that it generates not only direct but also indirect employment. For example, industries such as manufacturing, trade, and tourism are highly dependent on the transport sector.

The transport sector also accounts for a substantial share of energy consumption and carbon emissions. Approximately 30% of global energy consumption is attributed to

transport [22], while around 24% of CO_2 emissions are generated by this sector [23]. These figures highlight that, alongside its economic importance, the transport sector has significant environmental impacts. For this reason, “green transport” and decarbonization policies have become priority areas.
In the modern economy, the transport sector is a key component of logistics systems. The World Bank’s Logistics Performance Index (LPI) shows that countries with higher logistics performance tend to have greater export volumes, more stable supply chains, and faster economic growth. For example, countries ranking at the top of the LPI (such as Germany and Singapore) possess highly developed transport infrastructure [24].
The transport sector generates a multiplier effect on the economy. This effect manifests itself in several ways, including the reduction of production costs, expansion of markets, increase in investments, and enhancement of interregional integration. Empirical studies suggest that every 1 dollar invested in transport infrastructure can generate 2–3 dollars of economic returns in the long run [25].

3.2 The Transport Sector in the Economy of Azerbaijan

The transport sector is considered one of the strategic sectors of the Azerbaijani economy, and the country’s geoeconomic position further enhances its importance. Azerbaijan serves as a key transit country connecting Europe and Asia, which strengthens the role of the transport sector in economic growth. According to the World Bank, the development of transit and logistics capabilities is one of the main directions of economic diversification in countries such as Azerbaijan [10]. Particularly in the context of non-oil sector development, transport infrastructure plays a crucial role in ensuring economic stability.
According to statistical indicators, the transport and storage sector holds a significant share in the Azerbaijani economy. Data from the State Statistical Committee of Azerbaijan show that the share of the transport and storage sector in GDP has fluctuated between approximately 6–8% in recent years. In 2023, this sector accounted for around 7% of GDP. Within non-oil GDP, its share is even higher, estimated at approximately 8–10%.
These figures indicate that the transport sector is not merely a supporting component but also one of the leading sectors of the national economy.
One of the main characteristics of Azerbaijan’s transport sector is its role as a transit country. The country is located along several major international transport corridors, including the East–West corridor (Middle Corridor / Trans-Caspian International Transport Route) and the North–South International Transport Corridor. According to UNCTAD, the development of transit routes significantly increases the trade turnover of countries in the region [17]. In recent years, the Government of Azerbaijan has invested substantial resources in transport infrastructure, covering highways, railways, port infrastructure, and air transport.
The transport sector plays a vital role in Azerbaijan’s foreign trade. Statistical data indicate that a large share of export and import operations is carried out through transport infrastructure, while the volume of transit cargo has shown steady growth in recent years. The World Economic Forum notes that countries with higher-quality logistics and transport systems demonstrate greater trade competitiveness [15].

Azerbaijan's role in the "Middle Corridor" is particularly significant in this regard, as it serves as an alternative route in China–Europe trade. The transport sector also has a substantial impact on employment in Azerbaijan, creating thousands of direct jobs and generating indirect employment in logistics, trade, and tourism sectors.

The transport sector also occupies an important place in energy consumption in Azerbaijan. According to the International Energy Agency, the transport sector accounts for a significant share of energy consumption and contributes to carbon emissions. In this context, alternative fuels, electric vehicles, and "green logistics" are becoming priority areas in Azerbaijan as well.

The indirect effects of the transport sector on the Azerbaijani economy are reflected in the development of the non-oil sector, regional economic integration, expansion of the tourism sector, and attraction of foreign investment. Empirical assessments suggest that transport infrastructure projects generate a high multiplier effect in the economy and stimulate long-term growth [10].

3.3 Existing Challenges and Solutions in the Implementation of Innovations in the Transport Sector

The implementation of innovations in the transport sector is of critical importance for enhancing the competitiveness of the global economy and achieving sustainable development goals. However, the large-scale adoption of technological advancements in this field faces a range of economic, institutional, technical, and social barriers. A systematic analysis of these challenges is essential for improving the effectiveness of innovation policies.

First and foremost, financial and investment constraints represent one of the primary obstacles to innovation implementation. The transport sector is highly capital-intensive, and the adoption of new technologies—such as electric vehicles, intelligent transport systems (ITS), and autonomous transport—requires substantial initial investments. In developing countries, limited public budgets and the risk-averse nature of the private sector hinder the financing of innovative projects. Moreover, the long payback period reduces investor interest [26].

Another significant challenge is the inadequacy of institutional and regulatory frameworks. In many countries, the legal basis for implementing innovative transport technologies is either underdeveloped or unable to keep pace with rapid technological changes. For instance, issues related to legal liability, safety standards, and ethical considerations concerning autonomous vehicles remain insufficiently regulated in many jurisdictions. This creates uncertainty and slows down the pace of innovation adoption [27].

The uneven development of technological infrastructure also constitutes a major constraint. The effective functioning of technologies such as ITS, digital platforms, and electric charging infrastructure requires a modern technical base. However, particularly in developing regions, such infrastructure is either insufficient or entirely absent. This leads to regional disparities in innovation adoption and results in the concentration of technologies in specific geographic areas [28].

Another critical issue is the shortage of human capital and expertise. The implementation of innovative technologies requires highly skilled professionals, yet many countries face limitations in this regard. Additionally, there is often a lack of training and reskilling programs to adapt the existing workforce to new technological requirements. This restricts the effective utilization of technologies and slows productivity growth [29].

Social acceptance and behavioral factors also play a crucial role in the innovation process. Public distrust toward new technologies, particularly in the case of autonomous transport and sharing economy models, remains a significant barrier. Concerns related to safety, privacy, and job displacement delay the acceptance of innovations and create a mismatch between technological advancement and social adaptation [30].

Furthermore, environmental and sustainability-related challenges must be considered. Although many innovations, such as electric vehicles, aim to reduce carbon emissions, their production and disposal may generate new environmental issues. In particular, the extraction of rare metals required for battery production and the management of waste remain unresolved challenges. This necessitates a comprehensive assessment of the overall environmental impact of innovations [31].

Finally, issues related to international coordination and standardization also affect the implementation of innovations. Given the global nature of transport, technological compatibility and interoperability are essential. However, differences in standards across countries and weak coordination hinder the widespread adoption of innovations, particularly in logistics and international transportation.

Based on the findings of numerous studies, addressing these challenges requires comprehensive and multi-level solutions encompassing public policy, market mechanisms, and technological development.

First, to overcome financial constraints, the application of innovative financing mechanisms is essential. Public-private partnerships (PPP), green bonds, and support from international financial institutions can play a key role in this regard. In particular, subsidies and tax incentives for low-carbon transport projects can enhance private sector investment. Additionally, risk-sharing mechanisms can facilitate investor participation in innovative initiatives.

To address institutional and regulatory challenges, the modernization of legal frameworks is a fundamental requirement. Governments should develop flexible and adaptive regulatory environments for emerging technologies such as autonomous vehicles and AI-based systems. The “sandbox” approach—testing innovations in controlled environments—is considered effective in reducing risks and accelerating regulatory adaptation [32].

The development of technological infrastructure requires long-term strategic planning. Investments in ITS, 5G networks, electric charging infrastructure, and digital logistics platforms should be increased. At the same time, ensuring balanced regional development is necessary to enable the broader geographical diffusion of innovations.

Human capital development is a key pillar of the innovation process. Higher education institutions should expand specialized programs in transport engineering, data analytics, and artificial intelligence. Furthermore, lifelong learning approaches and professional training programs should be strengthened to facilitate the rapid adoption of new technologies [29].

Enhancing social acceptance requires effective public awareness and communication strategies. Increasing public knowledge about new technologies and addressing concerns related to safety and privacy through transparent information sharing are essential. Pilot projects and real-life applications can help build public trust. For example, successful implementations of sharing economy models and electric vehicles can have a positive impact [30].

To address environmental challenges, the concept of "green innovation" should be strengthened. The application of circular economy principles in the production and disposal of electric vehicles, as well as the promotion of battery recycling and the use of alternative materials, is essential. Moreover, integrating transport policy with urban planning can contribute to reducing carbon emissions [31].

Finally, international cooperation and standardization are critical for the widespread diffusion of innovations. Harmonizing technical standards, facilitating data exchange, and implementing joint research initiatives can enhance the effectiveness of innovation processes. Strengthening coordination mechanisms is particularly important in cross-border transport projects.

Overall, the successful implementation of innovations in the transport sector depends not only on technological advancement but also on effective economic policies, institutional flexibility, and social adaptation. A comprehensive and inclusive approach is essential for achieving long-term sustainable outcomes.

3.4 Econometric Estimations

The limited availability of official statistical data on innovation expenditures in Azerbaijan's transport sector creates significant methodological challenges in conducting the research. In the country, indicators related to innovation activity are generally collected at the aggregate economy level and are not disaggregated by sectors, particularly not for the transport sector. This makes it impossible to directly measure innovation expenditures specifically within the transport sector and necessitates the use of alternative approaches.

For this reason, within the scope of the present study, total national research and development (R&D) expenditures in Azerbaijan are used as an indirect proxy to evaluate innovation activity in the transport sector. This approach is widely applied in international empirical literature and is particularly common in countries where data limitations exist. In developing economies such as Azerbaijan, where the economic structure is still heavily influenced by the energy sector and sectoral disaggregation of innovation indicators is not fully developed, the use of macro-level indicators is considered more appropriate.

In recent years, Azerbaijan has undertaken several initiatives aimed at promoting innovation and technological development. Measures implemented within state programs, digitalization strategies, and infrastructure projects have indirectly influenced the transport sector as well. In particular, the introduction of logistics innovations, intelligent transport systems, and digital management mechanisms is closely linked to the overall development of the innovation environment. In this context, national R&D expenditure reflects the broader scientific and technological capacity that plays a crucial role in shaping innovations implemented in the transport sector.

On the other hand, the limited availability of sector-specific innovation indicators in Azerbaijan's statistical database makes it difficult to obtain consistent and comparable time-series data. This may negatively affect the reliability of econometric estimations. The use of aggregate R&D expenditure partially addresses this issue by allowing the construction of a longer and more stable data set. Thus, the selected proxy variable represents an optimal choice in terms of both data availability and analytical relevance. However, it should be noted that total R&D expenditures do not fully capture innovation activity specifically within the transport sector and are subject to certain limitations. Nevertheless, since this indicator reflects the overall level of innovation activity in the country, the direction of technological development, and the emergence of a knowledge-based economy, it can be considered an indirect proxy for innovative changes occurring in the transport sector.

Given the absence of specific statistical data on innovation expenditures in Azerbaijan's transport sector, the use of national R&D expenditures is a methodologically justified approach from both theoretical and practical perspectives. This choice enables the assessment of the overall impact of innovation activity in line with the objectives of the study and serves as the most suitable alternative under existing data constraints.

The Fully Modified Ordinary Least Squares (FMOLS) method is a semi-parametric estimation technique developed by Peter C. B. Phillips and Bruce E. Hansen (1990) for estimating long-run relationships. This approach is widely used for more accurate and reliable estimation of cointegration relationships between non-stationary time series variables.

The main advantage of the FMOLS method is that it eliminates the problems of endogeneity and serial correlation encountered in the classical Ordinary Least Squares (OLS) approach. In models with non-stationary variables, correlations may arise between explanatory variables and the error term, leading to biased and inconsistent OLS estimators. FMOLS addresses this issue by applying corrections based on the long-run covariance matrix, providing asymptotically unbiased and efficient estimates [33].

A key requirement for the application of this method is that the variables must be integrated of the same order (typically I(1)) and that a cointegration relationship must exist among them. Therefore, prior to applying FMOLS, cointegration tests such as the Phillips–Ouliaris cointegration test or the Johansen test should be conducted. When cointegration is confirmed, FMOLS provides reliable estimates of long-run elasticities and relationships.

Another important feature of FMOLS is its semi-parametric nature. This means that no strict assumptions are imposed regarding the distribution of the error term. Instead, the long-run covariance structure is estimated using spectral density methods. This approach allows for more stable results, even in small sample sizes.

In the literature, FMOLS has been widely applied in macroeconomic and sectoral studies. Overall, FMOLS is considered a powerful and reliable tool for estimating long-run relationships in studies involving non-stationary time series. In this research, given the presence of cointegration among variables, the FMOLS approach has been employed to estimate the long-run effects of factors influencing the development of the transport sector. Accordingly, FMOLS is used to empirically assess the impact of innovation on the development of Azerbaijan's transport sector. The econometric model includes the following variables: total profit in transport at current prices (million AZN) – total_prof_tr; value added in transport at current prices (million AZN) – value_tr; internal expenditures on research and development (thousand AZN) – r_d; number of employees in transport (thousand persons) – labour_tr; and gross fixed capital investment (million AZN) – invest_tr. The dataset for these variables is obtained from the State

Statistical Committee of the Republic of Azerbaijan. Descriptive statistics of the variables are presented in the table below.

Table 1. Descriptive statistics of the variables

Mean	3819.929	4876.214	156305.7	133.8143	2953.643
Median	3801.500	4793.000	138670.0	127.0500	2433.500
Maximum	6895.000	8823.000	262520.4	168.8000	5863.000
Minimum	1903.000	2369.000	92778.20	112.2000	1391.000
Std. Dev.	1705.921	2161.806	48286.51	16.65163	1390.087
Skewness	0.531184	0.521117	0.831788	0.714987	1.068886
Kurtosis	2.082768	2.045752	2.722631	2.402087	2.808634
Jarque-Bera	1.149132	1.164824	1.659243	1.401356	2.687237
Probability	0.562949	0.558549	0.436214	0.496249	0.260900
Sum	53479.00	68267.00	2188279.	1873.400	41351.00
Sum Sq. Dev.	37832165	60754254	3.03E+10	3604.597	25120435
Observations	14	14	14	14	14

Within the framework of the study, the descriptive statistical results of the variables under investigation enable a general assessment of their distributional properties. The results indicate that, across all variables, the proximity of the mean and median values suggests that the distributions are approximately symmetric in nature. However, in some variables, the mean exceeding the median points to the presence of positive skewness.

Relatively high standard deviation values, particularly for certain variables, indicate a high degree of variability and volatility in the data. This reflects the presence of fluctuations between observations over time. The skewness coefficients, which measure asymmetry, are positive for all variables, indicating that the distributions are right-skewed. At the same time, kurtosis values below 3 suggest that the distributions are platykurtic, meaning they are flatter compared to the normal distribution.

According to the Jarque–Bera test results used to examine the assumption of normality, the probability values for all variables exceed 0.05. This implies that the null hypothesis cannot be rejected, indicating that the variables follow a normal distribution.

Overall, the descriptive statistical results demonstrate that the variables exhibit characteristics close to normal distribution, while also showing a certain degree of variability and positive skewness. These properties confirm the suitability of the data for subsequent econometric analyses.

In this study, two models were employed to empirically assess the impact of innovation on transport development. First, an econometric model was specified to evaluate the effects of research and development expenditures, the number of employees in the transport sector, and investments in fixed capital within the transport sector on the growth of total transport profits. For this purpose, in order to determine the existence of cointegration relationships among the variables, the cointegration tests proposed by Robert F. Engle and Clive W. J. Granger [34], as well as Peter C. B. Phillips and Sam Ouliaris [35], were conducted.

Table 2. Results of the Engle–Granger Cointegration Test Based on the FMOLS Method

Cointegration Test - Engle-Granger
Specification: LOG(TOTAL_PROF_TR) LOG(R_D(-3)) LOG(LABOUR_TR(-2)) LOG(INVEST_TR(-1)) DUMMY18 C
Null hypothesis: Series are not cointegrated

	Value	Prob.*
Engle-Granger tau-statistic	-6.432963	0.0381
Engle-Granger z-statistic	-13.64794	0.0241

Table 3. Results of the Philips–Ouliaris Cointegration Test Based on the FMOLS Model

Cointegration Test - Phillips-Ouliaris
Specification: LOG(TOTAL_PROF_TR) LOG(R_D(-3)) LOG(LABOUR_TR(-2)) LOG(INVEST_TR(-1)) DUMMY18 C
Null hypothesis: Series are not cointegrated

	Value	Prob.*
Phillips-Ouliaris tau-statistic	-6.821772	0.0265
Phillips-Ouliaris z-statistic	-13.64912	0.0241

Based on the obtained results (Tables 2 and 3), a cointegration relationship among the variables has been identified.
To empirically estimate the impact of research and development expenditures on total transport profits, the Fully Modified Ordinary Least Squares (FMOLS) method was applied, and the corresponding model was specified. The following results were obtained:

$$\text{LOG(TOTAL\_PROF\_TR)} = 1.3984758828*\text{LOG(R\_D(-3))} + 2.14051261176*\text{LOG(LABOUR\_TR(-2))} - 0.322250841278*\text{LOG(INVEST\_TR(-1))} + 0.140058574775*\text{DUMMY18} - 16.1155353028 \quad (1)$$

Table 4. Specification of Model (1) Estimated via the FMOLS Method

Dependent Variable: LOG(TOTAL_PROF_TR)
Method: Fully Modified Least Squares (FMOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(R_D(-3))	1.398476	0.381015	3.670396	0.0214
LOG(LABOUR_TR(-2))	2.140513	0.715090	2.993346	0.0402
LOG(INVEST_TR(-1))	-0.322251	0.081699	-3.944378	0.0169
DUMMY18	0.140059	0.052847	2.650263	0.0570
C	-16.11554	2.067078	-7.796288	0.0015
R-squared	0.970417	Mean dependent var		8.437133
Adjusted R-squared	0.940834	S.D. dependent var		0.273125
S.E. of regression	0.066435	Sum squared resid		0.017655
Long-run variance	0.002166			

The results presented in Table 4 indicate that, in the long run, an increase in research and development expenditures has a positive effect on total profits in the transport

sector. Specifically, a 1% increase in research and development expenditures leads to a 1.4% increase in the transport sector after a three-year lag.
At the same time, in order to empirically assess the impact of research and development expenditures on the growth of value added in the transport sector in Azerbaijan, cointegration tests were first conducted.

Table 5. Results of the Engle–Granger Cointegration Test Based on the FMOLS Method

Cointegration Test - Engle-Granger
Specification: LOG(VALUE_TR) LOG(R_D(-3)) LOG(LABOUR_TR(-2)) LOG(INVEST_TR(-1)) DUMMY17 C
Null hypothesis: Series are not cointegrated

	Value	Prob.*
Engle-Granger tau-statistic	-6.944101	0.0238
Engle-Granger z-statistic	-12.79882	0.0942

Table 6. Results of the Philips–Ouliaris Cointegration Test Based on the FMOLS Model

Cointegration Test - Phillips-Ouliaris
Specification: LOG(VALUE_TR) LOG(R_D(-3)) LOG(LABOUR_TR(-2)) LOG(INVEST_TR(-1)) DUMMY17 C
Null hypothesis: Series are not cointegrated

	Value	Prob.*
Phillips-Ouliaris tau-statistic	-7.365745	0.0163
Phillips-Ouliaris z-statistic	-12.79860	0.0942

Based on the obtained results (Tables 5 and 6), a cointegration relationship among the variables has been identified. For the purpose of econometric estimation, the relevant equation was specified, and the following results were obtained.

LOG(VALUE_TR) = 1.13584524646*LOG(R_D(-3)) + 3.11913964109*LOG(LABOUR_TR(-2)) - 0.465178311474*LOG(INVEST_TR(-1)) - 0.207303426116*DUMMY17 - 16.3850950825 (2)

The econometric estimation results (Table 7) indicate that, in the long run, research and development expenditures have a positive effect on the growth of value added in the transport sector. Specifically, with a three-year lag, a 1% increase in research and development expenditures leads to a 1.13% increase in value added in the transport sector.

Table 7. Specification Characteristics of Model (2) Estimated via the FMOLS Method

Dependent Variable: LOG(VALUE_TR)
Method: Fully Modified Least Squares (FMOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(R_D(-3))	1.135845	0.377347	3.010080	0.0395
LOG(LABOUR_TR(-2))	3.119140	0.811624	3.843087	0.0184
LOG(INVEST_TR(-1))	-0.465178	0.100368	-4.634741	0.0098
DUMMY17	-0.207303	0.068241	-3.037827	0.0385

C	-16.38510	1.997064	-8.204592	0.0012
R-squared	0.981972	Mean dependent var		8.678604
Adjusted R-squared	0.963944	S.D. dependent var		0.276181
S.E. of regression	0.052442	Sum squared resid		0.011001
Long-run variance	0.002069			

Thus, the conducted econometric estimations reveal that, in the long run, an increase in research and development expenditures in Azerbaijan has a positive effect on both total profits and value added in the transport sector, with a three-year lag. Accordingly, increasing national research and development expenditures is considered appropriate in order to enhance these two variables.

Conclusion

The conducted analysis and existing theoretical approaches indicate that innovation has a positive impact on the development of the transport sector, as in many other sectors. In particular, a wide range of studies have shown that innovations contribute to reducing operational costs in the transport sector, increasing operational efficiency in freight transportation, ensuring higher turnover growth, enabling more flexible and adaptive management of transport systems, reducing traffic congestion, mitigating environmental problems, and positively influencing various sectors of the economy as a whole. The recent increase in state support for the transport sector in our country has stimulated the development of this area. However, considering the existing potential of the country, further development of the transport sector appears feasible.

To empirically assess the impact of innovation on the development of the transport sector in Azerbaijan, the FMOLS method was employed. Due to the limited availability of macro-level statistical data on innovation in our country, research and development expenditures were used as the proxy independent variable. Using the FMOLS approach, the econometric effects of research and development expenditures on total profits and value added in the transport sector were estimated. The results indicate that, in the long run, an increase in research and development expenditures leads, with a three-year lag, to a positive increase in both total profits and value added in the transport sector. Therefore, increasing research and development expenditures is considered essential.

An examination of the trend of research and development expenditures over the years in our country shows an upward trajectory. However, it should be noted that the current level of growth is not sufficient. Specifically, research and development expenditures as a share of GDP are approximately 0.2%. In most developed and developing countries, this indicator is significantly higher, ranging between 1% and 4%. For this reason, increasing research and development expenditures in the country is regarded as a key priority. To this end, attracting companies to the research sector is considered more appropriate. At present, the share of the private sector in research and development expenditures is very low; therefore, several measures could be effective in increasing it, including strengthening and expanding linkages between the private sector and research centers, implementing incentive mechanisms such as tax benefits, and allocating appropriate state subsidies for research funding.

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