

OPPORTUNITIES FOR IMPROVING THE EFFICIENCY OF THE AGROLOGISTICS SYSTEM IN THE REPUBLIC OF ARMENIA

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Key words: logistic efficiency, vehicle load factor, economic feasibility, logistic costs per GDP, freight turnover

Introduction

The assessment of the economic efficiency of the agrologistics system helps to reveal the level of logistics organization within a given country and the extent to which it contributes to the growth of gross domestic product and the development of agriculture. This assessment is particularly evident in countries with already advanced logistics systems, where logistics costs are being optimized day by day and supply chain management practices are continuously improved. The opportunities for improving the efficiency of the agrologistics system in developing countries such as the Republic of Armenia can be examined from various perspectives and compared with the indicators of countries that already possess advanced logistics systems, as well as with international standards. As is well known, Armenia's logistics system is characterized by a number of obstacles-economic, technical, and qualitative in nature.

Methodology

At the macro level, the efficiency of logistics in the agricultural sector is also determined by the country's international relations, the state of its transport infrastructure, geographical location, climatic conditions, and the ability to ensure uninterrupted freight transportation. Therefore, logistics requires consideration of the multiplier effect and evaluation of its efficiency across various dimensions such as reliability, sustainability, adaptability, financial performance, the quality of logistics services for consumers, and others.

In order to assess the overall efficiency of the logistics system, it is necessary to consider not only value-based indicators, but also certain qualitative indicators such as average delivery times, the rate of damaged or spoiled goods, the level of customer satisfaction, the number of incidents during transportation, and the duration of freight delivery.

Literature review

Over time, various experts and scholars have proposed their own approaches to evaluating the economic efficiency of logistics. For instance, Martin Christopher considered the overall integration of the supply chain as a key to an efficient logistics system, placing particular emphasis on the optimal use of resources, reduction of time, and customer satisfaction [Christopher, 2016, 43-45]. Christopher was among the first to implement the monitoring of Key Performance Indicators (KPIs), which allow for the operational cont-

rol and improvement of supply chain processes. These indicators include average delivery time, vehicle load factor, regional supply volume growth, and others.

Jean-Paul Rodrigue, in his work, emphasizes the importance of geographical, temporal, and infrastructural factors in logistics systems. Specifically, for evaluating the efficiency of logistics systems, the key objects of his study include the capacity of transport infrastructure, freight turnover, and the speed of the supply chain [Rodrigue, 2020, 104-111].

Polina Arshinina and Albina Kiseleva identify five main indicators for assessing the efficiency of a logistics system. These are: total logistics costs, the quality of logistics services, the overall performance level of the system, the total duration of logistics processes, and their quality [Arshinina, Kiseleva, 2020, 3-6].

Scientific Novelty

The simplest way to evaluate the economic justification of the agrologistics system is to determine the ratio between the system's investments and the expected economic benefits. This method assesses not only direct costs but also indirect costs and, in particular, the benefits – such as reduced losses, increased productivity, and improved market conditions. Such analysis demonstrates the extent to which the system operates in an economically profitable manner.

Analysis

Total logistics costs are formed based on the activities, management, and aggregated expenditures associated with each component of the system. These costs can be classified into three main categories: operational logistics costs, administrative costs, and logistics costs allocated for potential risks.

In the context of evaluating and analyzing the economic efficiency of a logistics system, it is also appropriate to consider the level of a country's foreign trade activity—in other words, to analyze the ratio of trade turnover to GDP. This analysis helps to reveal the degree of economic integration, the volume of logistics flows, the demand for investments, and the level of infrastructure load in different countries. Thus, as is well known, a high export-to-GDP ratio typically reflects a country's level of economic development, while a high import-to-GDP ratio indicates a low level of self-sufficiency and a strong dependence on foreign trade.

Total logistics costs are directly correlated with a country's level of logistics development; in other words, the higher the costs, the more extensive the country's external and internal freight turnover. In many developed countries, significant attention is paid to the share of logistics costs within their GDP. It is generally accepted that in countries with a high level of logistics development, logistics costs can reach, and sometimes even exceed, 10% of GDP.

Table 1. Total Logistics Costs as a Percentage of GDP in Selected Countries with Advanced Logistics Systems. (%)

Countries	Logistic Costs	Year
USA ¹	8.7 %	2023
China ²	14.5 %	2023
South Korea ³	13.6 %	2021
Thailand ⁴	13.9 %	2022
Singapore ⁵	1.94 %	2020
EU ⁶	10-15 %	2021

An analysis of the above table reveals that in nearly all of the listed countries, logistics costs as a percentage of GDP exceed 8%, indicating the presence of well-developed logistics systems. At the same time, the relatively low logistics cost ratio in the United States does not imply that its logistics system is inferior to those of other countries. On the contrary, it is generally regarded as one of the most advanced in the world. As of 2023, total logistics expenditures in the U.S. amounted to approximately USD 2.3 trillion. The relatively low logistics cost ratio in the U.S. is mainly due to the country's exceptionally large GDP and the multi-billion dollar allocations distributed across various sectors of its economy. On the other hand, Singapore-a rapidly developing country not only from a logistics perspective but also in many other respects, does not exceed even 2% of GDP in terms of logistics costs, which is primarily due to the country's small geographic size.

Macroeconomic indicators are also used to evaluate the economic efficiency or productivity of a country's transport system, such as the ratio of revenue or expenditures from freight transportation to the country's GDP. This indicator reflects the role of the transport system within the overall national economy. The ratio between trade turnover and total logistics costs makes it possible to determine how much is spent within the supply chain to carry out a given volume of total exports and imports. Accordingly, a lower percentage derived from the formula $\text{logistics costs/trade turnover} \times 100\%$ indicates the efficient performance of the logistics system.

¹ https://cscmp.org/CSCMP/CSCMP/Educate/State_of_Logistics_Report.aspx

² <https://www.worldbank.org/en/news/speech/2017/05/22/performance-and-prospects-of-global-logistics>

³ <https://www.statista.com/statistics/892961/south-korea-logistics-costs-as-a-percentage-of-gdp/>

⁴ https://ticycity.com/en/ticy_city_en/ticy_movement_en/14144/logistics-cost-to-gdp-ratio-for-the-year-2022/

⁵ https://vynncapital.com/wp-content/uploads/2021/11/Vynn-Capital_Singapore-Logistics-Report.pdf

⁶ https://joint-research-centre.ec.europa.eu/scientific-activities-z/transport-sector-economic-analysis_en

Table 2. Revenue and Expenditures from Freight Transportation in the Republic of Armenia at Current Prices, Excluding VAT (million AMD)¹

	2020	2021	2022
Overall			
revenue	79478.4	80631.0	93147.0
costs	61881.2	64124.6	76200.6
<i>among them</i>			
railway			
revenue	17729.7	16878.8	19267.2
costs	14464.8	13644.6	14450.7
road			
revenue	61606.1	63422.7	72383.7
costs	47375.1	50040.5	60585.2
air			
revenue	142.6	329.5	1496.1
costs	41.3	493.5	1164.7

Among the economic indicators presented in the above table, the most striking is the share of revenue generated by freight transported by road, which averaged about 78 % of total freight revenue during 2020–2022. According to Table 2, in 2022 total revenue from freight transportation rose by 15 % compared with 2021, with growth observed across all modes of transport. In the last reporting year, profit from freight transportation reached AMD 16,946.4 million (total revenue minus total expenditures), while the profitability ratio amounted to 18.1 % (profit / revenue × 100 %).

Thus, the table once again underscores the dominant role of road transport in Armenia's overall freight turnover, while simultaneously highlighting the cost-intensiveness of air transport for freight movements in the country. Specifically, the profitability of air transport was approximately –50 % in 2021 yet improved to 22 % in 2022. The favorable economic indicator for air freight in 2020 was due exclusively to humanitarian and military aid received under wartime conditions and does not characterize the inherent efficiency of this mode within the logistics system.

As is well known, Gross Domestic Product (GDP) reflects the total market value of all goods and services produced within a country's territory. It simultaneously indicates the size of the national economy, the level of economic activity, the pace of economic growth, and the overall well-being of the population. Thus, based on Armenia's GDP figure for 2022, which amounted to 8,501,449.4 million AMD, it is possible to calculate the share of total freight transportation expenditures within the GDP². This share is app-

¹ <https://www.armstat.am/file/doc/99541118.pdf>

² <https://www.armstat.am/am/?nid=12&id=01001>

roximately 1 %, which is considered a very low indicator, once again highlighting the underdevelopment and low efficiency of the logistics system in Armenia.

From a technical standpoint, key indicators for assessing the economic efficiency of the logistics system include: freight turnover (ton*kilometers), vehicle load factor (tons per vehicle), return on investment in the system, inventory turnover ratio, revenue and profit relative to logistics expenditures, and logistics labor productivity (tons per employee, tons per hour). Freight turnover is commonly calculated based on the total volume of goods transported over an average distance, expressed in tons. This indicator is internationally recognized and is typically analyzed or compared by using freight turnover per capita (ton*km/person) or per unit of area (ton*km/km²), along with its growth rate expressed as a percentage.

Table 3. Freight Turnover Volumes in Selected Countries (billion ton*kilometers)¹

Countries	Freight Turnover	Year
Armenia	4.809	2023
Iran	32.92	2021
Georgia	13.6	2023
Germany	710.9	2022
France	174	2022

The level of freight turnover largely depends on factors such as a country's territorial size, logistics infrastructure, industrial activity, geographic location, accessibility of supply chains, and international relations. In 2024, the freight turnover in the Republic of Armenia amounted to approximately 4.8 billion ton-kilometers, which is nearly three times lower than that of neighboring Georgia and about eight times lower than Iran's (table 3). The primary reason for this is not only Armenia's relatively small territory compared to its neighbors, but also its lack of direct access to the sea and border closures on the eastern and western sides. On the other hand, the high level of freight turnover in European countries such as Germany, France, Italy, the Netherlands, and others is mainly ensured by the free market trade conditions within the European Union and the high level of industrial and agricultural development in those countries.

In the agrologistics system of Armenia, transportation costs are the highest in the region. This is primarily due to high fuel prices, poor road quality, and limited accessibility, all of which frequently lead to road accidents, excessive fuel consumption, and increased

¹ <https://www.armstat.am/am/?nid=12&id=05001>

depreciation costs. In addition, transportation of agricultural products requires refrigerated conditions with stable temperature control, which increases fuel consumption by 30–40% compared to standard dry freight transport. Furthermore, the fleet of refrigerated trucks in Armenia is relatively old and worn out, which further contributes to inefficient fuel usage and elevated operational expenses.

Despite the noticeable decline in the agricultural sector in Armenia in recent years, a significant portion of the country's exports still consists of agricultural products and goods derived from their processing. In 2023, only 13.8% of Armenia's foreign trade turnover accounted for exports of agricultural products, while 10.2% related to imports of such products. According to the recorded data for 2023, the total trade turnover of the Republic of Armenia amounted to USD 21.3 billion, of which USD 8.5 billion was generated by exports (table 4).

Table 4. Republic of Armenia's 2023 Foreign Trade Food Balance by Agricultural Products (million USD)¹

Type	Export	Import
Live Animals and Products of Animal Origin	101.3	249.6
Products of Plant Origin	185.3	358.7
Oils and Fats	1.5	66.6
Prepared Food Products	892.4	631.7
Total Agricultural Products	1180.5	1306.3
Total Industrial Products	7371.5	11465.4
Overall	8552	12763

It is well known that agricultural products of local origin exported from the Republic of Armenia, despite unstable logistics conditions, continue to maintain their demand in foreign markets. This is largely due to the presence of large Armenian diaspora communities abroad and the high quality standards of the exported goods.

Thus, although agricultural products represent a relatively modest share of overall trade turnover (in comparison with industrial goods), Armenia's agrologistics system is in urgent need of efficiency improvement. It is evident that the logistics system of the Republic of Armenia is predominantly based on industrial logistics (over 85%), and therefore, logistics-related reforms – particularly at the state level – will primarily target the development of the system as a whole. However, the agrologistics system, as a subsector, will also require specific professional and technical enhancements to ensure its effective integration and contribution.

¹ <https://armstat.am/file/doc/99556248.xlsx>

Table 5. Operational Length of Communication Routes in the Republic of Armenia (km)

	2018	2019	2020	2021	2022
Railway Lines	793.5	789.4	782.1	782.1	818.1
<i>including</i>					
public use	703.2	703.2	703.2	703.2	725.6
private use	90.3	86.2	78.9	78.9	92.5
Motor Roads	10742.9	11416.5	11274.0	11306.2	11306.4
<i>including</i>					
public use	7575.0	7630.3	7513.6	7543.2	7543.2
private use	3167.9	3786.2	3760.4	3763.0	3763.2
Trunk Gas Pipelines	1586.5	1586.5	1583.9	1583.9	1594.4

When discussing the efficiency of the logistics system in the Republic of Armenia, it is essential to also consider the country's infrastructure, particularly the length and quality of communication routes utilized within the system.

According to the data presented in table 5, it can be stated that over the past five reporting years, the total operational length of Armenia's communication routes has remained largely unchanged. Only in 2022 there was a 36-kilometer increase in the total length of railway lines and an approximately 10-kilometer expansion in the gas pipeline network. From the data presented in the above table, it becomes clear that highways play a key role in carrying out logistic freight transportation in the Republic of Armenia. However, the data from table 5 also show a certain decline in the total length of roads in recent years, which, of course, has a bit impact on the scale of freight turnover.

The public communication routes currently in operation in Armenia generally provide adequate connectivity between the capital and the provinces. However, ensuring a sustainably developed logistics system requires the availability of one or more alternative routes to existing roads, which would help to unload the main transport corridors and increase the speed of freight transportation within the country.

This need becomes even more evident in light of Armenia's complex mountainous terrain, where not only is transportation speed reduced, but cargo safety is also compromised. In such conditions, the construction of alternative interstate and national roads becomes increasingly vital for the development of a more resilient logistics network.

Thus, taking into account Armenia's relatively small territory, the main transportation routes, and the nearly unchanged total length of operational communication networks, it is possible to estimate the average transportation distance for cargo moved by both general and individual means of transport in 2023. This estimation will be based on the 2022 data regarding the operational length of overall and specific communication routes, as the growth dynamics of these indicators from 2018 to 2022 have remained virtually zero.

Accordingly, the average transportation distance for freight is calculated by dividing the freight turnover indicator of 2022 by the corresponding freight volume for that year. Based on this method, the average distance for all modes of cargo transportation in 2022 was estimated at 282.8 kilometers. This figure can reasonably be projected onto 2023 with minimal deviation, as no significant changes occurred in the operational length of Armenia's communication routes between 2022 and 2023.

However, the same cannot be said for the years 2020–2021, during which the average distances were 315.9 km and 295 km, respectively. These variations were influenced by geopolitical developments in the country, which led to a partial reduction in the length of operational routes during that period.

By examining the average transport distance of cargo moved via individual modes of communication in 2022, we note that the average distance for road freight transportation was 78.6 km (calculated as 1,041.6 million ton*kilometers / 13.2 million tons), while for rail transportation, it was 259.1 km (calculated as 907.1 million ton*kilometers / 3.5 million tons). Deriving this indicator also allows us to estimate the total and mode-specific freight volumes in 2023 using the following approach:

Transported Cargo (tons) = Freight Turnover (ton*kilometers) / Average Distance (km)

Based on Armenia's 2023 freight turnover indicator, it can be estimated that the total volume of transported cargo in 2023, with minor deviations, amounted to approximately 17 million tons (calculated as 4,809 billion ton*kilometers / 282.8 km). Of this total, road transportation accounted for approximately 14.6 million tons, and rail transportation for about 2.04 million tons.

It should be noted that these figures encompass not only exports and imports of goods in 2023, but also all domestic freight movements as well as international transit shipments that passed through Armenia, where the Republic of Armenia functioned as a transit (third-party) country.

Additionally, it is worth emphasizing that freight volume projections by mode of transport are more accurate than aggregated total indicators, as they take into account the aggregate transportation distances across all four modes of transport available in Armenia.

Another important indicator that reflects the level of logistical activity within an economy is the freight transportation intensity index, which shows how much cargo is transported annually per capita. Based on this indicator, it can be concluded that in 2023, Armenia's freight transportation intensity amounted to approximately 6.1 tons per person, calculated using the most recent demographic data (17 million tons / 2.8 million people). However, this indicator is not entirely conclusive, and its comparison across countries is

only meaningful when population density and settlement patterns are approximately similar.

Based on the available data, it is also possible to assess the density of individual operational communication routes. Thus, during 2022–2023, the total length of automobile roads in the Republic of Armenia amounted to approximately 380 kilometers per 1,000 km² (calculated as $11,306.4 \text{ km} / 29,743 \text{ km}^2 \times 1,000$). The corresponding figures for railway lines and gas pipelines were 27.5 km and 53.6 km, respectively.

Another technical indicator that reflects the volume of freight transported annually per kilometer of road or railway is freight density. Based on 2023 data, freight density along Armenia's road network was approximately 1,290 tons per kilometer (14.6 million tons / 11,306.4 km), while rail freight density was 2,494 tons per kilometer (2.04 million tons / 818.1 km).

Conclusion

By analyzing the overall logistics system of the Republic of Armenia, with particular emphasis on the efficiency of the agrologistics sector, several key conclusions can be drawn—each of which presents considerable opportunities for improvement. To conduct a precise and comprehensive evaluation of the logistics system, it is essential to consider it from multiple perspectives.

When evaluating the economic efficiency of Armenia's logistics system at the macro level, it is important to consider the ratio of total logistics costs to the country's GDP. As previously mentioned, freight transportation costs typically account for around 45% of total logistics expenditures. Given that, as of 2023, freight transport costs in Armenia amounted to approximately 1% of GDP, it can be inferred that total logistics costs accounted for about 2.2% of GDP in the same year. This indicator clearly reflects the low level of investment and underdevelopment within Armenia's logistics system. From this perspective, improving the efficiency of the logistics sector in Armenia will also require an increase in public investments and subsidies, or in other words, a significant rise in logistics expenditures as a share of GDP, bringing it closer to 8-10% in line with international benchmarks.

Armenia's logistics system remains technically underdeveloped, as the limited number of infrastructure elements—such as alternative roads, bridges, tunnels, and railways—along with their non-compliance with international standards, hinders the smooth flow of both domestic and international freight transportation. In this context, for example, the planned completion of the North–South interstate highway will significantly contribute to improving the efficiency of the country's logistics system. It will increase the total operational length of communication routes, expand Armenia's infrastructure base (including

27 bridges and 9 tunnels), enhance the overall speed of cargo transportation, and substantially support the growth of both external and internal freight turnovers.

One of the key reasons for the low efficiency of Armenia's agrologistics system, from a technical perspective, is the insufficient number of specialized storage facilities. These facilities are primarily located in the outskirts of Yerevan and major regional centers and fail to meet the overall demand for storage and packaging of perishable goods. This issue is especially acute in border regions and customs checkpoints, where there is often a need to store agricultural products in refrigerated conditions to avoid large-scale spoilage. In this regard, the establishment of several dry and refrigerated warehouses in various regions of the country-particularly in Syunik, Shirak, Lori, and Tavush-would positively contribute to enhancing the efficiency of Armenia's agrologistics system.

An analysis of the technical efficiency indicators of Armenia's logistics system reveals that the country has significant potential to expand both domestic and foreign trade through improved transport connectivity. The road density per unit of area in Armenia clearly falls short of European standards, which significantly complicates the supply process from the regions. In this context, based on regional engineering assessments, it is possible to implement infrastructure improvements to ensure uninterrupted inbound and outbound freight transportation for agricultural and industrial zones.

The construction of alternative roads across the territory of the republic, along with their appropriate reinforcement through tunnels and bridges and the improvement of asphalt road quality, will have a direct impact on enhancing freight turnover, increasing freight density, and improving transportation speed. These developments will contribute to the expansion of both domestic and international freight volumes. The establishment and upgrading of new transport routes will also make it possible to bypass and relieve the burden on currently slow, inaccessible, and overloaded roads, while simultaneously reducing transportation risks.

The expansion of communication routes can also be achieved through the extension of railway lines, creating interregional connections within Armenia-for example, between Gegharkunik - Vayots Dzor - Syunik, Shirak - Aragatsotn - Armavir, Tavush - Gegharkunik - Ararat. Currently, Armenia's railway network has low density, particularly in border regions. Within the broader vision for the development of interstate logistics, the creation of a direct railway link along the Iran-Armenia - Georgia - Black Sea corridor (including the Meghri - Kapan - Sisian-Sotk section) would fundamentally enhance the role and significance of the Republic of Armenia in international trade.

Thus, even a 1-kilometer increase in the average operational length of communication routes can significantly enhance the technical efficiency of the supply chain. According to Armenia's 2023 data on freight volumes and average transport distances, an increase

of just 1 km in the average transport distance would result in a growth of approximately 18 million ton*kilometers in road freight turnover, and about 1.6 million ton*kilometers in rail freight turnover.

In conclusion, it must be emphasized that improving the efficiency of the agrologistics system in Armenia requires a range of multifaceted solutions. These measures would significantly increase the volume of freight turnover, stabilize transportation processes, enhance the attractiveness of Armenia for international freight operators, and ultimately reduce overall logistics costs in the country. To that end, the implementation of public investments and subsidies in Armenia will contribute to attracting larger-scale assets to the sector. Naturally, a significant increase in revenues should not be expected in the short term, as this process requires long-term investments and consistent follow-up. However, from the perspective of individual entrepreneurs, the logistics system will become considerably more attractive, ultimately leading to a reduction in their transportation costs.

In Armenia's logistics system, investments must be primarily directed toward the development of infrastructure, including the expansion of alternative roads, tunnels, bridges, and railway lines. A key priority is to increase the speed and efficiency of interstate routes, which are currently hindered by adverse weather conditions, inaccessible mountain passes, and poor asphalt quality.

Since the article primarily focuses on logistics within the agricultural sector, it is important not to overlook the significant losses of agricultural goods resulting from spoilage due to the chronic congestion at border checkpoints and prolonged customs procedures. In this regard, the establishment of specialized storage facilities across the country, particularly in border regions, is more than necessary to ensure the proper unloading, storage, and packaging of all types of freight transported by truck.

Finally, the establishment of a unified railway network throughout the territory of Armenia would not only multiply the volume of freight transportation, but also play a critical role from a strategic national perspective. The proposed railway system-enabling uninterrupted freight movement with Armenia's northern and southern neighboring countries-would contribute to resolving the country's food security challenges and lay the foundation for the development of new infrastructure in the regions.

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The agro logistics system is a multifunctional logistics framework that encompasses all processes related to the collection, storage, processing, packaging, transportation, and distribution of agricultural products. Therefore, the efficiency of the logistics system is determined by improvements in each of these stages, as well as by a range of external factors. The Republic of Armenia, classified as a developing country from a logistics perspective, currently faces a range of challenges. Overcoming these challenges would contribute to setting higher benchmarks in foreign trade and ensuring the operation of a more stable and sustainable logistics system. Accordingly, the objective of this article is to assess the current state of the agro logistics system in the Republic of Armenia, to identify the key challenges hindering its sustainable development, and ultimately to reveal and substantiate the opportunities for improving its efficiency. The overall efficiency of the logistics system will be evaluated not only through value-based indicators, but also by means of qualitative and technical metrics. These will be compared with those of countries that have advanced logistics systems. As a result, a plan for the development of new infrastructure will be proposed, which will include the establishment of alternative domestic road routes, their appropriate reinforcement with tunnels and bridges, the improvement of the quality of paved roads, the expansion of the railway network across the country, and the construction of new specialized warehouses.