The role of Transport Logistics in Promoting Algeria's Economic Growth: Econometric Study for the period 1990-2021

دور لوجستيك النقل في تعزيز النمو الاقتصادي في الجزائر: دراسة قياسية للفترة 1990-2021

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Abstract:

This study examines the role of transportation logistics in promoting economic growth in Algeria during the period 1990-2021, using the Autoregressive Distributed Lag (ARDL) model. The study employs data on the volume of goods transported by sea, air, road, and rail as logistics indicators, while Gross Domestic Product (GDP) serves as an indicator of economic growth. The results obtained indicate a long-term positive relationship between transportation logistics and economic growth. The results obtained indicate a positive relationship in both short and long terms between transportation logistics and economic growth. The Toda-Yamamoto causality test suggests that transportation logistics does not impact economic growth, and vice versa. Based on the proposed model, it can be concluded that logistics services play a significant role in enhancing economic growth in Algeria.

Keywords: *Transportation Logistics, Economic Growth, ARDL Model, Toda-Yamamoto Test .*

ملخص:

تبحث هذه الدراسة في دور لوجستيك النقل في تعزيز النمو الاقتصادي في الجزائر خلال الفترة 1990-2021، باستخدام نموذج الانحدار الذاتي للفجوات الزمنية الموزعة ARDL، من خلال بيانات حجم البضائع التي تنتقل عبر البحر والجو والبر والسكك الحديدية كمؤشر لوجستي، في حين يتم استخدام الناتج المحلي الإجمالي كمؤشر للنمو الاقتصادي. توضح النتائج التي تم الحصول عليها على وجود علاقة إيجابية في الأجلين القصير والطويل بين لوجستيك النقل والنمو الاقتصادي، أما اختبار Toda-Yamamoto للسببية يشير إلى أن لوجستيك النقل لا يؤثر على النمو الاقتصادي والعكس صحيح. واستنادا إلى النموذج المقترح، يمكننا أن نستنتج أن الخدمات اللوجستية تساهم بشكل مهم في تعزيز النمو الاقتصادي للجزائر.

الكلمات المفتاحية: *لوجستيك النقل، النمو الاقتصادي، نموذج ARDL، اختبار Toda-Yamamoto.*

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1 Introduction:

In light of current international developments, transportation logistics emerges as a critical catalyst for economic growth, contributing significantly to enhanced trade and overall economic development. Logistics, encompassing the processes involved in managing goods within the supply chain from raw material acquisition to production and consumption, plays a pivotal role, especially in transportation across diverse stages of the supply journey. An efficient logistics system not only amplifies economic growth but also fosters seamless integration into the global economy.

Like any developing country, Algeria is actively striving to elevate its services by strategically incorporating logistics activities into its broader development plans. Additionally, the country is committed to establishing advanced infrastructure, providing it with a competitive edge in service delivery and harnessing modern technologies. This concerted effort aligns with the broader global trend, emphasizing the pivotal role of logistics in shaping economic trajectories and fostering international connectivity.

Given the aforementioned points, we have formulated the following problem statement:

- **What is the role of transportation logistics in promoting economic growth in Algeria during the period 1990-2021?**

Hypotheses of the Study:

Based on the formulated research problem, we have proposed the following hypotheses:

- There is a positive impact between transportation logistics and economic growth in Algeria during the period 1990-2021;
- There is long-term relationship in econometric model between transportation logistics and economic growth in Algeria;
- There is a causal relationship between transportation logistics and economic growth in Algeria.

The study's objectives:

The primary objective of the study is to analyze and measure the impact of transportation logistics on economic growth in Algeria during the period 1990-2021, in both the long and short terms, using a econometric approach through the AutoRegressive Distributed Lag (ARDL) model.

Study Methodology:

In this study, we have adopted a descriptive methodology to present various theoretical aspects of the topic. We also utilized the same methodology to analyze the evolution of study variables and to interpret the empirical outcomes of previous studies regarding the impact of transportation logistics on economic growth.

Study Structure:

To address the research problem, we have structured the study into two main axes as follows:

1. The theoretical and conceptual framework of transportation logistics systems and economic growth.

2. The empirical study of the impact of transportation logistics on enhancing economic growth in Algeria for the period 1990-2021.

2 Literature review:

Many previous studies have explored the relationship between transport logistics and economic growth and aimed to determine the impact between these two factors. Some of these studies include:

Mayache's study (2021) delves into the correlation between logistics variables and economic growth in Algeria, utilizing data from 1990 to 2017 and employing factor analysis and regression analysis. The study identifies three key components—communications, trade, and industry, with no significant relationship found between transportation and economic growth. (Mayache, 2021)

In a research effort by Merzouki et al. (2021), titled "Impact of the Transport Sector on Economic Growth in Algeria: A Standard Study Using the ARDL Model (1980-2017)," the ARDL cointegration model is used to assess the relationship between various transportation sectors (road, maritime, railway) and economic growth. The study reveals a positive long-term equilibrium relationship between the transport sector and economic growth, except for the aviation sector, which exhibits an inverse relationship. (Merzouki, Ramdani, & Zahwani, 2021)

The research by Huang and team (2006) focuses on the dynamic relationship between the development of logistics services and GDP growth in China. Analyzing data from 1952 to 2004, the study employs cointegration analysis and error correction modeling, highlighting a robust cointegration relationship between GDP growth and the expansion of logistics services. (Huang, Li , & Liu , 2006)

Reza (2013) introduces an econometric model regarding the Relationship Between Logistics and Economic Development in Indonesia. This study utilizes time series data on traffic volume and economic growth from 1988 to 2010, applying various tests, including cointegration and Granger causality tests. The results underscore the significant role of logistics services in supporting and sustaining economic growth, with economic growth attracting demand for logistics services. (Reza, 2013)

These studies collectively contribute to our understanding of the relationship between logistics and economic growth and provide insights into specific country contexts.

3 The Theoretical and Conceptual Framework of Transportation Logistics Systems and Economic Growth:

3.1 Transportation Logistics Systems:

Logistics activities are among the most significant modern fields that contribute to ensuring an efficient flow of goods, guaranteeing production continuity, and minimizing costs. Therefore, in this section, we will delve into the nature of logistics systems and the importance of transportation logistics.

3.1.1 The Concept of Logistics Systems and Their Elements:

Logistics is a broad concept and consists of the transportation of raw materials obtained from suppliers to production facilities, as well as the movement and storage of raw materials and finished products within facilities, and the delivery of raw materials and finished products to distribution centers, retail stores, or end users. (Katı, Yıldırım, & Demirc, 2019, p. 146)

From another perspective, logistics is "that part of supply chain management that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements". (Osayuwamen , 2018, p. 20)

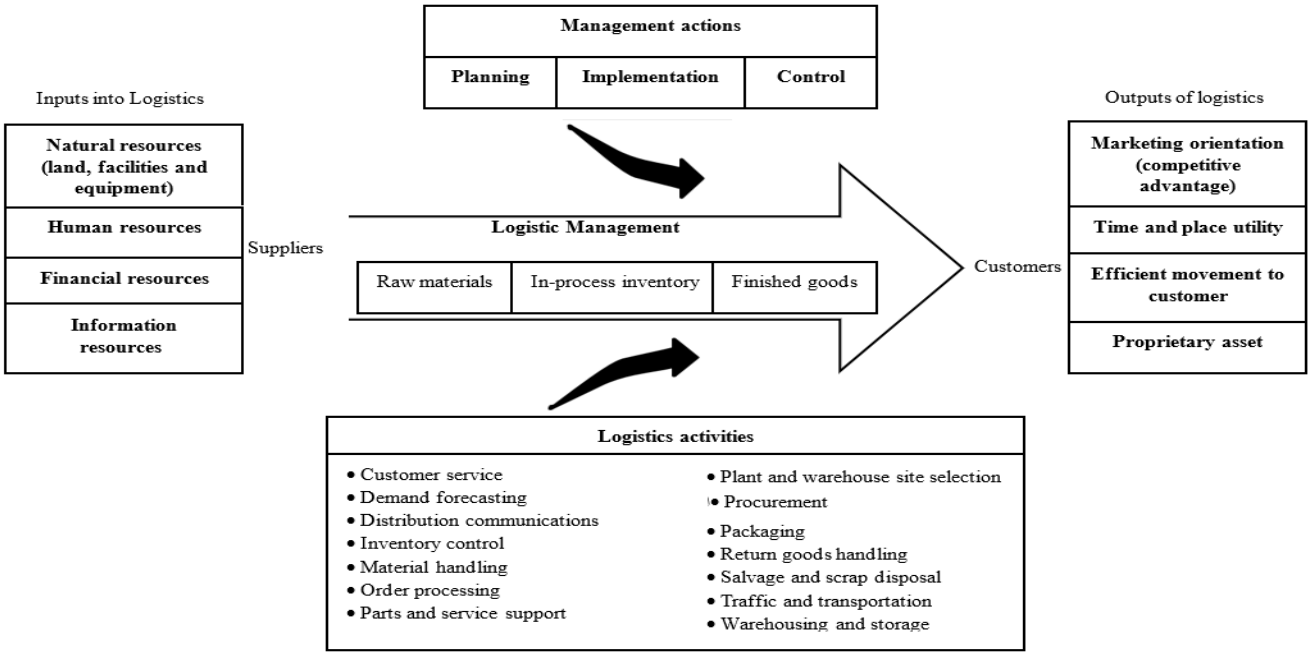
Logistics services are also defined as the process of planning, executing, and monitoring the efficient, cost-effective flow and storage of raw materials, inventory during the process, finished goods, and relevant information from the point of origin to the point of consumption for the purpose of meeting customer requirements .(Hsin-I, 2009, p. 22)

Based on the previous definitions, it becomes clear that the integrated system of transportation, storage, and distribution of goods includes several components or elements, which are (Lachin, 2009, p. 56):

1) Transportation;
2) Storage activity;
3) Subsidiary storage location selection;
4) Inventory management;
5) Material handling;
6) Document cycle;
7) Protective packaging for the product;
8) Customer service;
9) Information flow activity;
10) The relationship between resources and consumer.

The total inputs and outputs of the components of the logistics system can also be illustrated in the following figure:

Figure 1: Components of the Logistics System.



The source: *Birol Erkan, (2014), p 1234.*

These elements collectively form the integrated logistics system, wherein each activity is interconnected with the others. The ultimate objective is for these activities and components to

collectively achieve the efficient transportation and distribution of goods and raw materials from their sources of origin at the lowest possible cost, in the shortest possible time, and with a high level of satisfaction for the end users of the goods. (Lachin, 2009, p. 57)

3.1.2 Transportation logistics:

Transportation logistics is considered one of the fundamental activities in logistics. It's unimaginable that any organization could carry out its activities without providing the necessary movement for the required raw materials or the final products that need to be marketed and supplied to customers in the market. (Lachin, 2009, p. 35)

The logistics activity related to transportation is evident through three main activities (Baatouche, 2016, pp. 94-95):

1) **Network Design**: This involves determining transportation networks by focusing on the delivery method of goods, transportation risks, availability of logistical services along each transportation route, and selecting the most cost-effective and suitable network for the specific type of goods ready for transportation.
2) **Transportation Operations Planning**: This activity includes predicting and specifying the appropriate timing, quantities, and locations for transporting goods. This allows for advanced adjustments and achieving necessary balances while considering the actual available transportation capacities and truck loading ratios.
3) **Fleet Management:** This activity primarily revolves around administrative and technical organization of transportation vehicles. It encompasses all activities aimed at monitoring vehicle utilization, ensuring their availability, and managing transportation needs effectively.

3.1.3 The Economic Impact of Logistics Activities:

logistics services are instrumental in accelerating economic growth, reducing poverty, and facilitating economic transactions, making them a vital component of today's economies.

They play a pivotal role in today's economy, and the market for logistics services has reached a significant level in many economies. The economic effects of logistics services can be analyzed as follows:

- **Acceleration of Economic Growth and Productivity**: Logistics activities contribute to accelerating economic growth and increasing productivity while reducing poverty. There is substantial evidence that trade liberalization is associated with faster productivity growth among companies in developing countries. Increased trade due to extensive liberalization, under the right conditions, can promote economic and social development by boosting productivity and reducing poverty. In such cases, the logistics sector plays a critical role in the process;
- **Cost Impact:** Logistics is one of the major expenses for businesses, and it both influences and is influenced by other economic activities. Improving logistics efficiency can reduce costs and impact profitability positively;
- **Facilitating Economic Transactions**: Logistics supports the movement and flow of numerous economic transactions. It is a critical activity in facilitating the sale of nearly all goods and services. To understand this role from a systems perspective, consider that if goods do not arrive on time, customers cannot purchase them. If goods do not reach the right place or in

the right condition, no sales can occur. Consequently, all economic activities throughout the supply chain would suffer;

- **The Economic Implications of Logistics Services:** Logistics may serve as the most significant source of a company's competitive advantage because it is less replicable than other elements of the marketing mix: product, price, and promotion. Consider, for example, that establishing a close and ongoing relationship with transportation companies or logistics service providers can give a company a distinct competitive advantage in terms of speed, reliability, availability, or other customer service factors;
- **Effective logistics services are a critical factor in determining a country's competitive capability** just as they are for a company. International transportation systems may suffer from insufficient coordination across countries in the network, such as inconsistent schedules, customs delays, incongruent standards, and inadequate information flow about delays. Logistics services help address these issues. For example, they assist customers in cost-saving by focusing on cargo flows, reducing empty trips, and encouraging information sharing among transport contractors;
- **Enhanced logistics performance delivers products to markets with competitive quality and prices.** Efficient logistics services do not only reduce transportation costs and transit times but also decrease production costs. If logistics services are inefficient, companies are likely to maintain higher inventories at each stage of the production chain, requiring additional working capital (larger warehouses for storing larger inventories);
- **Increased logistics efficiency means** that socially essential goods like basic foodstuffs can be transported within countries more rapidly and at lower costs;
- **Thanks to logistics efficiency**, farmers can access entirely new markets, either in different regions or possibly at an international level;
- **Logistics services serve as a source of employment.** Many logistics-related operations require intensive labor. Logistics operations tend to be relatively more labor-intensive in developing countries than in advanced economies due to differences in production technology. (Birol , 2014, pp. 1246-1247)

In summary, logistics services can be a key driver of a company's competitive advantage and contribute significantly to economic development and efficiency on both a company and country level.

3.2 The Nature of Economic Growth:

Economic growth is a tool for reducing poverty and improving the quality of life in developing countries, as research provides compelling evidence that rapid and sustainable growth is of paramount importance in achieving faster progress towards development goals. Strong economic growth promotes human development, which, in turn, enhances economic growth.

3.2.1 Concept of Economic Growth:

Economic growth, in its limited sense, is defined as an increase in individual income during a particular period and involves the analysis of this process, especially quantitatively, focusing on the functional relationships between local variables. In a broader sense, it involves an increase in gross domestic product (GDP), gross national product (GNP), and national income, thereby increasing national wealth. This is expressed through absolute and relative per capita output, which also includes structural adjustments to the economy. (Haller, 2012, p. 66)

Economic growth can also be defined as "the ability of the national economy to increasingly provide various goods and services to the population." This ability is built on the available structural framework of the national economy, technological advancement, and the size of various resources available to society. (Mebrak & Deradji, 2022, p. 67)

In essence, economic growth signifies an increase in the national income and wealth of a country over time, reflecting its capacity to produce more goods and services for its population. This capacity is influenced by factors such as technological advancements, resource availability, and structural adjustments within the economy.

So, economic growth isn't just about an increase in income; it encompasses the broader development of a nation's economy and its ability to provide for its citizens' needs and aspirations. (Pavitar , 2012, p. 15)

There are situations when economic growth is confounded with economic fluctuations. The application of expansionist monetary and tax policies could lead to the elimination of recessionary gaps and to increasing the GDP beyond its potential level.

Economic growth supposes the modification of the potential output, due to the modification of the offer of factors (labour and capital) or of the increase of the productivity of factors (output per input unit). (Haller, 2012, p. 67)

When the rate of economic growth is big, the production of goods and services rises and, consequently, unemployment rate decreases, the number of job opportunities rises, as well as the population's standard of life. Some economists state that a rate of the GDP growth of 3% a year allows a rise of the potential GDP with 10% in three years and a doubling in 23 years. According to the "rule of 70", a rate of growth of 1% doubles the potential GDP over a period of seventy years (Angelescu C., 2005)

3.2.2 Types of Economic Growth and their Sources:

3.2.2.1 Types of Economic Growth:

There are three main types of economic growth: spontaneous growth, transient growth, and planned growth. Here's an explanation of each type (Bahiani, 2020-2021, p. 07) :

1) **Spontaneous Growth:** This type of growth occurs naturally from the internal forces within the national economy, without following a scientific planning approach at the national or regional level. It is typically slow, gradual, and continuous, although it may experience short-term fluctuations;
2) **Transient Growth:** Transient growth lacks continuity and stability. It occurs in response to external and usually transient factors. These factors are typically outside of the economy and disappear along with the growth they induced;
3) **Planned Growth:** This type of growth results from comprehensive planning of the resources and requirements of society. The effectiveness of this growth model is closely related to the capabilities of planners, the realism of the plans, the efficiency of execution, and monitoring, as well as the involvement of the public in the planning process at all levels.

3.2.2.2 Sources of Economic Growth:

The following factors are usually considered the most important sources of economic growth:

1) **Quantity and Quality of the Workforce**: The size and skill level of the labor force play a significant role in economic growth;
2) **Quantity and Quality of Natural Resources:** The availability and quality of natural resources, such as minerals, energy sources, and arable land, can greatly impact economic growth;
3) **Quantity and Quality of Real Capital:** The level of physical capital (machinery, infrastructure, etc.) and its quality contribute to economic growth;
4) **Technological Advancement:** The level of technological development achieved by society is a crucial source of economic growth.

These variables are considered the fundamental factors that determine economic growth, as they define the productive potential of any economy. (Bahiani, 2020-2021, p. 10)

3.2.3 Impact of Logistics Development on Economic Growth:

Several studies indicate a positive relationship between logistics development and economic growth. The development of logistics contributes to economic growth in four main ways:

1) **Boosts Direct Investments in Logistics**: Investment in logistics infrastructure and services increases the demand for related products and services. As businesses and industries invest more in logistics, it generates economic activity and stimulates growth.
2) **Efficient Logistics System Reduces Travel Time**: An efficient logistics system can significantly reduce travel times for both goods and people. This leads to cost savings for travelers and employees, making the overall economy more efficient and competitive.
3) **Improves Logistics Infrastructure Attracts Foreign Direct Investment**: Improved logistics infrastructure, such as better transportation networks and ports, makes a country more attractive to foreign investors. Foreign direct investment (FDI) can bring in capital, technology, and expertise, all of which can spur economic growth.
4) **Reduces Transportation and Trade Costs:** Lower transportation and trade costs, resulting from efficient logistics, can lead to increased production and trade. When it's cheaper and easier to move goods, businesses are more likely to engage in trade and expand their operations, ultimately driving economic growth. (Katı, Yıldırım, & Demirc, 2019, p. 147)

In summary, the development of logistics not only facilitates the movement of goods and services but also plays a vital role in stimulating economic growth by attracting investments, reducing costs, and enhancing the overall efficiency of an economy.

4 The Role of Transport Logistics in Enhancing Economic Growth in Algeria for the Period 1990-2021:

In this axis, we will study and analyze the evolution of goods movement through various means of transportation and economic growth in Algeria during the period 1990-2021. We will also examine the relationship between transport logistics and economic growth during the same period using the Auto-Regressive Distributed Lag (ARDL) time-series model.

4.1 Analysis of the Evolution of Goods Movement and Economic Growth in Algeria:

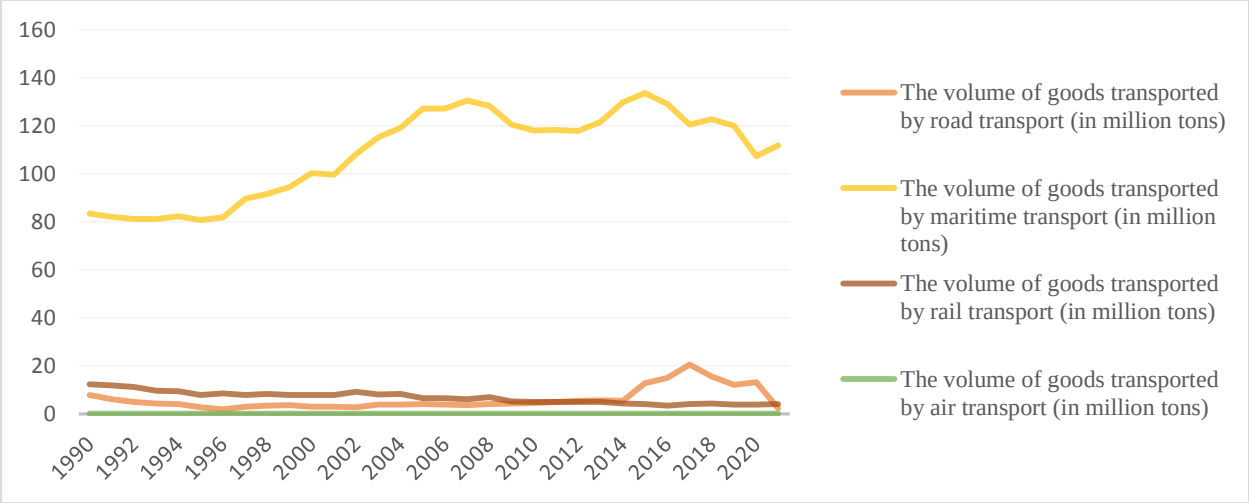
4.1.1 Evolution of the Volume of Goods Transported through Various Means of Transportation in Algeria:

The transportation sector in Algeria has undergone significant transformations through the completion of numerous projects and ongoing developments to make this sector more efficient. In Figure 02, we will illustrate the movement of goods volume through various means of transportation in Algeria during the study period. We observe that maritime transportation is the most efficient means of transporting goods compared to other methods in Algeria. The movement of goods increased substantially by approximately 50% between 1995 and 2006. Algerian ports handled about 130.3 million tons of goods in 2007, including 100.8 million tons of loaded goods and 29.5 million tons of unloaded goods. This growth can be attributed to the government's liberalization of the maritime transport sector in 2004 to enhance its effectiveness and competitiveness, as well as the privatization of Algerian ports starting in 2006. However, it can be said that Algerian ports still lag significantly in this field due to the heavy reliance on the national economy on the hydrocarbon sector, leading most commercial ports to be dedicated to oil transportation.

We also note a decline in the share of goods transported by rail, with around 9.25 million tons transported in 2002 compared to 4.18 million tons in 2021. This decline is attributed to the deterioration in service quality and the fragility of the infrastructure for most railways. As for road transport of goods, it is less important than rail transport, but we observe an increase in its contribution, with 12.81 million tons transported in 2015 compared to 5.45 million tons in 2014. However, it also suffers from some shortcomings, including irregularity in service users and non-compliance with specified schedules, which have limited its use.

Regarding air cargo transportation, it has the smallest share due to the monopoly of the market by Air Algeria, despite its liberalization and the emergence of private companies. However, these private companies faced financial difficulties due to corruption issues.

Figure 2: Evolution of the Volume of Goods Movement through Various Means of Transportation in Algeria.

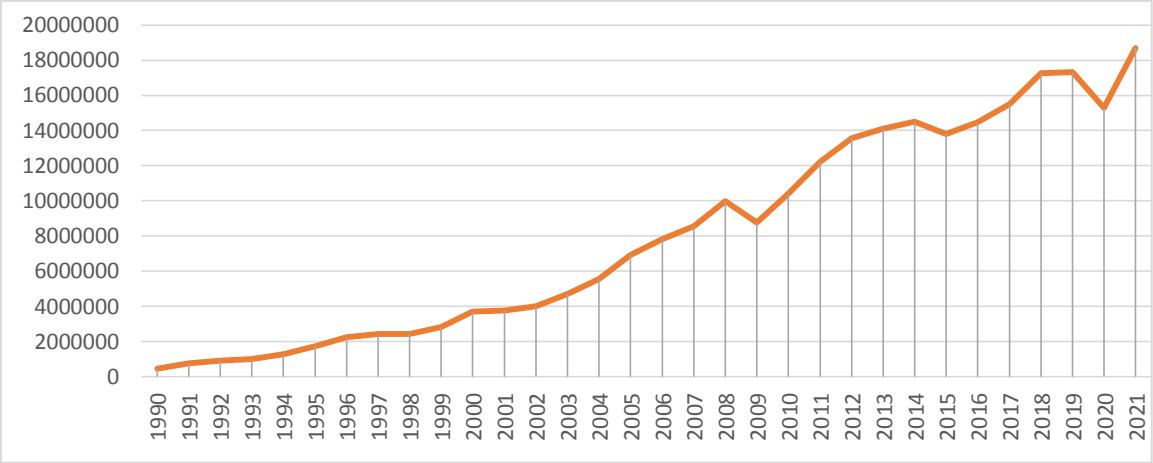


The source: *From the preparation of researchers based on the data of the Office National of statistics (ONS) and using Excel.*

4.1.2 Economic Growth Evolution in Algeria:

Economic growth in Algeria has witnessed several stages that have aligned with developments in the economy. These developments can be described as somewhat regular, as illustrated in the following figure:

Figure 3: Evolution of Gross Domestic Product (GDP) in Algeria during the period 1990-2021, Unit: in Million Algerian Dinars (DZD).



The source: *From the preparation of researchers based on the data of the Office National of statistics (ONS) and using Excel.*

In summary, Algeria was characterized by significant economic fluctuations during the period from 1990 to 2021, with periods of improvement and decline influenced by oil prices and local and global political and economic event. Through the above figure, we notice that the Gross Domestic Product (GDP) in Algeria has experienced continuous growth over the past years, marked by several changes and fluctuations resulting from the instability of the national economy as a whole during the period from 1990 to 2021. Starting from 1990 until 1997, there was a significant development, mainly due to the security situation in the country during the early 1990s, known as the "Black Decade," and the poor and deteriorating conditions of the sectors at that time : During this period, Algeria experienced a state of political and security turmoil, which had a negative impact on the economy. There was a deterioration in economic and social conditions.

the GDP began to improve, reflecting the economic reforms and development programs. During the period from 2001 to 2014, the GDP experienced a significant qualitative leap and a substantial increase in its value due to favorable financial conditions, primarily caused by the high oil prices at that time Oil prices significantly rose during this period, leading to increased government revenues and supporting economic growth.

However, it decreased in 2015 due to the decline in oil prices., global oil prices dropped, adversely affecting the Algerian economy., but quickly rebounded in 2016 until: 2019 In the following years (2016-2019) Recovery and Downturn, the Algerian economy partially recovered thanks to improved oil prices and additional economic reforms.

In 2020, due to the COVID-19 pandemic, the GDP declined once again, only to recover in 2021 thanks to the improvement in oil prices and the global economic recovery, marking a new economic momentum for the country.

Rise Again (2021): In 2021, Algeria saw an economic growth resurgence due to improved oil prices and the global economic recovery.

4.2 The empirical study:

To empirically study the role of transportation logistics in promoting economic growth in Algeria, there were challenges in terms of logistics indicators. Initially, it is difficult to obtain an index that can reflect the scope of logistics due to its broad concept covering various aspects including material handling, inventory, transportation, and storage. After reviewing previous studies, it can be observed that the common factor in all these aspects is merchandise. Therefore, in this research, we will use the volume of goods transported by sea, air, land, and rail as a logistics indicator, while we will use Gross Domestic Product (GDP) as an economic growth indicator. These data were collected from the National Office of Statistics (ONS) for the period from 1990 to 2021.

Based on the study's topic, the study variables are limited to:

- **Dependent Variable:** Represented by the natural logarithm of Gross Domestic Product, denoted as (**lgdp**).
- **Independent Variable**: Represented by the natural logarithm of transportation logistics (the sum of the volume of goods transported by sea, air, land, and rail), denoted as **(lltr).**

These variables will be analyzed using the Eviews13 economic measurement software to determine the long and short-term relationship between them, based on a set of approaches and tests. The Autoregressive Distributed Lag (ARDL) time-series regression methodology was adopted for this analysis.

4.2.1 The AutoRegressive Distributed Lag (ARDL):

Methodology for time series gaps is a dynamic model. These models are characterized by their ability to consider time dynamics (adjustment time, expectations, etc.) in interpreting a variable (time series), thereby enhancing forecasting and policy effectiveness (decisions, actions, etc.). Unlike the simple (non-dynamic) model that provides immediate interpretations (immediate or non-propagating effects) of the variable being explained, dynamic models take into account time dynamics and expected changes in variable explanations. In the family of dynamic models, there are three types of models (Kuma, 2018, p. 06):

If we consider the dependent variable Y_t and the independent variable X_t, we will notice the following:

- **Auto-Regressive (AR) Models:** These are dynamic models that rely on the impact of the dependent variable on itself over time. This impact is represented by the previous values of the dependent variable, meaning that past values of the variable can influence current values.

$$Y_t = f(X_t, Y_{t-p})$$

The term "auto-regressive" translates to regression of the variable on itself or on its lagged values.

- **Distributed Lag (DL) Time Series Models:** These models are also dynamic and are used to analyze the relationship between the dependent variable and explanatory variables over time. These models rely on time lags between consecutive values of the dependent variable and explanatory variables. These time lags represent changes in the consecutive values of the variable, and they can be used to estimate the impact of explanatory variables on the dependent variable over time.

$$Y_t = f(X_t, X_{t-q})$$

In summary, these models help understand how variables influence each other over time and how time-series data can be used to analyze these relationships and forecast future values of the dependent variable.

- **The AutoRegressive Distributed Lag (ARDL):** these models combine the characteristics of two previous ones; we find, among the explanatory variables (X_t), the lagged dependent variable (Y_{t-p}) and the past values of the independent variable (X_{t-q}). They have the following general form:

$$Y_t = f(X_t, Y_{t-p}, X_{t-q})$$

But these dynamic models generally suffer from issues of autocorrelation of errors, especially when the dependent variable is used as an explanatory variable (AR and ARDL models), and they are also multi-linear (DL and ARDL models), making parameter estimation challenging through Ordinary Least Squares (OLS) methods. In such cases, it is necessary to resort to robust estimation techniques like Seemingly Unrelated Regression (SUR), etc., to overcome these problems. Additionally, it should be noted that the variables considered in these models should be stationary to avoid spurious regressions. In its general form (explicit), an ARDL model is written as follows:

$$Y_t = \varphi + \alpha_1 Y_{t-1} + \cdots + \alpha_p Y_{t-p} + b_0 X_t + \cdots + b_q X_{t-q} + e_t$$

$$Y_t = \varphi + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=0}^{q} b_j X_{t-j} + e_t$$

With $e_t \sim (0, \sigma)$: the error bounds; «b_0» it reflects the short-term effect X_t on variable Y_t. Considering the long-term relationship or equilibrium relationship as follows: $Y_t = k + \phi X_t + u$. The long-term effect X_t on variable Y_t. (or "ϕ") can be calculated as follows:

$$\phi = {\sum b_j} \Big/ {(1 - \sum \alpha_i)}$$

As with any dynamic model, information criteria (AIC, SIC, HQ) will be used to determine the optimal lag (p* or q*); the optimal lag is the lag that provides the minimum value of one of these mentioned criteria. These criteria include the Akaike Information Criterion (AIC), the Schwarz Information Criterion (SIC), and the Hannan-Quinn Information Criterion (HQ) (Kuma, 2018, p. 07)

The application of the ARDL model requires us to: (Nkoro & Uko, 2016, p. 78)

- The ARDL technique can be applied regardless of whether core variables are I(0), I(1), or a combination of both. This helps to avoid the pretesting problems associated with standard cointegration analysis which requires the classification of the variables into I(0) and I(1).

- If the F-statistics (Wald test) show a single long run relationship and the sample size is small, ARDL error correction representation becomes relatively more efficient.
- If the F-statistics (Wald test) indicate multiple long-term relationships, ARDL cannot be applied. Alternative methods like Johansen and Juselius (1990) should be considered, especially if the dependent variable expressions reveal feedback effects (multiple long run relationships) between the variables.
- If trace, maximal eigenvalue, or F-statistics show a single long-term relationship, ARDL can be applied instead of Johansen and Juselius.

The methodology of ARDL can be summarized by following these steps (Abderrazak, 2018, p. 01):

1)Ensure that the variables are not integrated of order two by using unit root tests;
2)Formulate an unrestricted error correction model;
3)Determine the appropriate lag length for the model;
4)Ensure that the model errors are autocorrelation-free;
5)Ensure that the model is dynamically stable;
6)Conduct bounds testing to see if there is evidence of a long-run relationship between the variables;
7)If the result is positive in step 6, estimate the short-term and long-term relationships, as well as the unrestricted error correction model;
8)Use the estimated model results from step 7 to measure the dynamic effects of the short-term and long-term relationships between the variables.

4.2.2 Applying the ARDL model on the Study Variables:

4.2.2.1 Study of Time Series Stationarity:

To apply the Auto-Regressive Distributed Lag (ARDL) methodology, time series data should be either integrated of order zero I(0), integrated of order one I(1), or a mix of both. If the time series data is integrated of order two I(2), then the ARDL methodology cannot be applied. After conducting the Augmented Dickey-Fuller (ADF) test on the study's time series data, we extracted the results shown in the following table:

Table 1: Results of Time Series Stationarity Test for Study Variables.

variables	Test value ADF	the critical value 5%	the critical value10%	prob	decision
Lgdp	-2,42	-3,562	-3,215	0,3627	Not stationary
lltr	-1,706	-2,963	-2,621	0,4178	Not stationary
Dlgdp	-5,823	-3,568	-3,218	0,0002	stationary
Dlltr	-2,967	-2,963	-2,621	0,0497	stationary

***The source**: Prepared by the researchers based on the outputs from Eviews 13 software.*

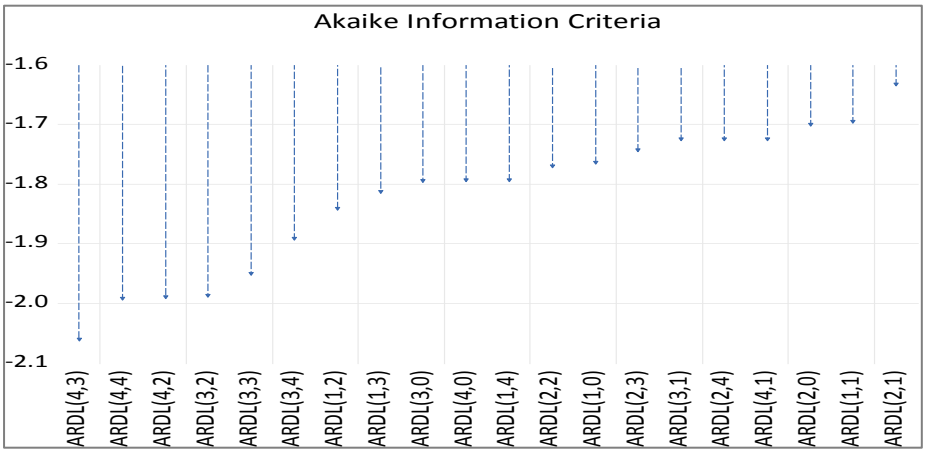
From the table, it is evident that both the time series of Gross Domestic Product (lgdp) and the Logistics Transport series (lltr) are not stationary at the level, as the absolute value of the Augmented Dickey-Fuller (ADF) test statistic is less than the critical values at the 1%, 5%, and 10% significance levels. However, when first differences are taken, the series become stationary, as the ADF test statistic is greater than the critical values at the 1%, 5%, and 10% significance levels. This indicates that both series are integrated of order one, I(1).

Therefore, it is appropriate to use the Autoregressive Distributed Lag (ARDL) approach for time series analysis.

4.2.2.2 To determine the optimal lag order and estimate the ARDL model:

To determine the optimal ARDL model, we used the Akaike Information Criterion (AIC), which provides statistically significant results with the fewest parameters. The results indicate that the optimal lag order is ARDL (4,3), as shown in the following figure:

Figure 4: Results of determining the optimal lag order.



***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

As it is evident, the ARDL model (4,3) is the best among the other 19 models presented because it yields the lowest AIC value. Furthermore, standard problems are automatically addressed according to the best model, and the upcoming diagnostic tests will illustrate that. Below are the estimation results for the optimal ARDL model:

Table 2: Selection of the Optimal ARDL Model (4, 3).

Dependent Variable: LGDP
Method: ARDL
Date: 08/30/23 Time: 21:03
Sample: 1994 2021
Included observations: 28
Dependent lags: 4 (Automatic)
Automatic-lag linear regressors (4 max. lags): LLTR
Deterministics: Restricted constant and no trend (Case 2)
Model selection method: Akaike info criterion (AIC)
Number of models evaluated: 20
Selected model: ARDL(4,3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGDP(-1)	0.593150	0.216818	2.735709	0.0131
LGDP(-2)	-0.253564	0.277369	-0.914176	0.3721
LGDP(-3)	0.043179	0.274311	0.157407	0.8766
LGDP(-4)	0.369403	0.189605	1.948274	0.0663
LLTR	1.027520	0.430220	2.388360	0.0275
LLTR(-1)	-1.443451	0.716977	-2.013247	0.0585
LLTR(-2)	0.245992	0.791980	0.310603	0.7595
LLTR(-3)	0.917066	0.536708	1.708686	0.1038
C	0.513751	0.785628	0.653937	0.5210

R-squared	0.993705	Mean dependent var	15.76160
Adjusted R-squared	0.991054	S.D. dependent var	0.804022
S.E. of regression	0.076046	Akaike info criterion	-2.059875
Sum squared resid	0.109876	Schwarz criterion	-1.631667
Log likelihood	37.83826	Hannan-Quinn criter.	-1.928968
F-statistic	374.9026	Durbin-Watson stat	1.941637
Prob(F-statistic)	0.000000		

***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

4.2.2.3 Diagnostic Tests for the Estimated ARDL Model:

We observe the absence of serial correlation issues in the errors, no problem of heteroskedasticity, and the residuals follow a normal distribution. Additionally, the validity of the lag structure used in the model is confirmed (Stability). These results can be summarized in the following table:

Table 3: Diagnostic Test Results for the Estimated ARDL Model.

Null Hypotheses	Tests	Probabilities
H_0: No Autocorrelation of Errors (Serial Correlation)	Breusch-Godfrey	**0,925**
H_0: No Heteroskedasticity	Arch-test	**0,936**
H_0: Residuals Follow a Normal Distribution	Jarque-Bera	**0,612**
H_0: Validity of the Lag Structure Used in the Model	Ramsey (Fisher)	**0,864**

***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

As observed from the table above, all the p-values are greater than the 5% significance level, indicating the acceptance of the null hypothesis for all these tests. Thus, we have statistically and empirically confirmed the validity of the model, making it reliable for analysis and study. This means that based on the results of the diagnostic tests, there is no evidence of autocorrelation of errors, heteroskedasticity, deviations from normality in the residuals, or issues with the lag structure used in the model. Therefore, the model can be considered statistically sound and suitable for further analysis and study.

4.2.2.4 Cointegration Test:

Before identifying the long and short-term relationship between variables, it is essential to test for cointegration using the Bound test. This test involves comparing the calculated test statistic (F-statistic) with critical values (boundaries) based on the following hypotheses:

- If F-statistic < Upper bound I(1): We conclude that there is cointegration.
- If F-statistic > Lower bound I(0): We conclude that there is no cointegration.
- If the F-statistic lies between the lower and upper bounds: It falls into a gray area (zone of doubt).

The results of the cointegration test can be summarized in the following table:

Table 4: Results of the Bound Test for Cointegration.

Test Statistic	Value					
F-stastistic	**10,270308**					
Significance	**10%**		**5%**		**1%**	
Critical Value Bounds	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	3,303	3,797	4,09	4,663	6,027	6,76

***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

The results of the Bound Test confirm the presence of a cointegration relationship between the study variables (with F-statistic=**10**,**27** > Critical Value Bounds at the 1%, 5%, and 10% significance levels). This suggests the possibility of estimating the long-term effects of logistics transport on economic growth.

In other words, the cointegration relationship implies that there is a stable long-term relationship between these variables, and changes in logistics transport may have a lasting impact on economic growth. This finding is significant for understanding the dynamics between logistics transport and economic growth in the long run.

4.2.2.5 Estimation of Long-Term Model and Error Correction Model:

4.2.2.5.1 Estimation of the Error Correction Model (ECM):

The coefficient of the error correction term, also known as the Speed of Adjustment, indicates the extent of the change in the dependent variable due to deviations of the independent variables in the short run from their long-term equilibrium values by one unit. It is expected that this coefficient is statistically significant and negative (Arab and Ben Bouziane, 2021, page 387). The results of estimating the Error Correction Model can be illustrated in the following table: (Arabe & Ben Bouziane, 2021, p. 387)

Table 5: Estimation results of the error correction model.

Dependent Variable: D(LGDP)
Method: ARDL
Date: 08/30/23 Time: 18:41
Sample: 1994 2021
Included observations: 28
Dependent lags: 4 (Automatic)
Automatic-lag linear regressors (4 max. lags): LLTR
Deterministics: Restricted constant and no trend (Case 2)
Model selection method: Akaike info criterion (AIC)
Number of models evaluated: 20
Selected model: ARDL(4,3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-0.247833	0.042469	-5.835596	0.0000
D(LGDP(-1))	-0.159017	0.174476	-0.911396	0.3724
D(LGDP(-2))	-0.412581	0.156711	-2.632755	0.0156
D(LGDP(-3))	-0.369403	0.179758	-2.055002	0.0525
D(LLTR)	1.027520	0.377704	2.720435	0.0128
D(LLTR(-1))	-1.163058	0.421508	-2.759277	0.0118
D(LLTR(-2))	-0.917066	0.477858	-1.919116	0.0687

***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

From the table above, it is evident that the error correction term coefficient is (-0.247833), which is negative and statistically significant (Prob=0.0000). This indicates the presence of a short-term equilibrium relationship between the variables and the existence of an error correction mechanism from the short term to the long term. Consequently, the studied model corrects errors by 24.78% within one period, which is a full year.

It is also clear that logistics transport has a positive and statistically significant impact on economic growth in Algeria in the short term. An increase of 1% in logistics transport leads to a 1.027% increase in economic growth. However, these effects are reversed over time, as logistics transport policies that were prevalent a year or two ago acted as a hindrance to economic growth in

Algeria. This can be attributed to the underdevelopment of infrastructure and economic systems in the country.

4.2.2.5.2 Estimation of the Long-Term Model:

Through the estimation of the ARDL model, the long-term relationship is determined as follows:

Table 6: Results of the Long-Term Model Estimation.

Cointegrating Specification

Deterministics: Rest. constant (Case 2)

CE = LGDP(-1) - (3.014634*LLTR(-1) + 2.072971)

Cointegrating Coefficients

Variable *	Coefficient	Std. Error	t-Statistic	Prob.
LLTR(-1)	3.014634	0.681981	4.420405	0.0002
C	2.072971	3.429287	0.604490	0.5508

Note: * Coefficients derived from the CEC regression.

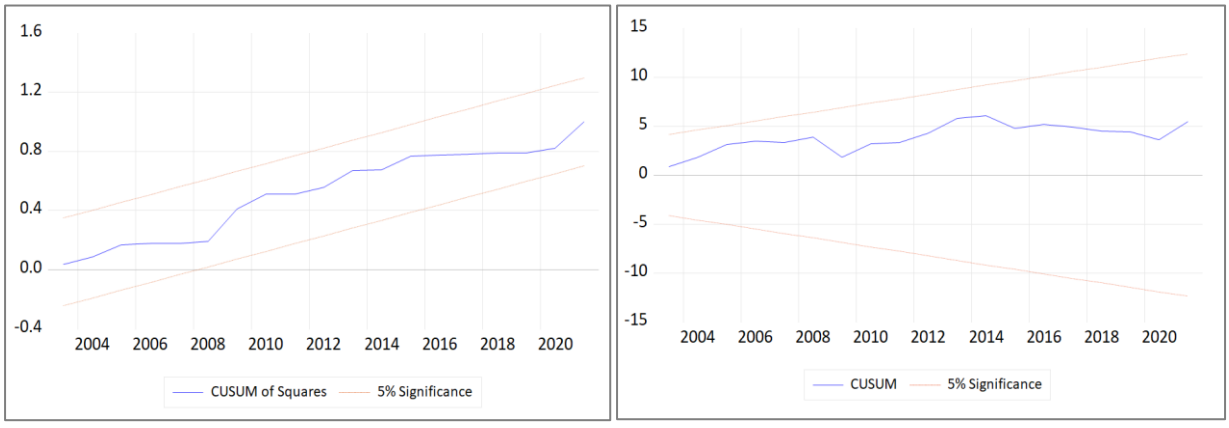
***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

The estimation results indicate a positive and statistically significant long-term effect of logistics transport on economic growth in Algeria, similar to the short-term impact. An increase of 1% in logistics transport leads to an acceleration of economic growth by 3.014% in the long term.

4.2.2.6 Structural Stability Test for the Model:

To test the structural stability of the model, the Cumulative Sum of Residuals (CUSUM) and Cumulative Sum of Squares of Residuals (CUSUMSQ) tests are used. Structural stability is achieved when the graphical representation of the statistics for both tests falls within the critical bounds at a 5% significance level. These tests also measure the degree of stability and coherence between long-term parameters and short-term parameters.

Figure 5: Results of the CUSUM and CUSUMSQ Tests.



***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

From the figure above, it is evident that the graphical representation of both CUSUM and CUSUMSQ statistics falls within the critical bounds, indicating that the estimated model coefficients are stable over the study period and are statistically acceptable. This suggests that the model is structurally stable and provides reliable results throughout the study period.

4.2.2.7 Toda-Yamamoto Causality Test:

The ARDL cointegration test, which demonstrates the relationship between variables in both the short and long run, does not indicate the direction of causality between the variables. This makes the estimation results incomplete. Granger (1969) stated that the purpose of the estimation results is not to find the relationship between variables but to test the causality between them. This enhances the estimation results because it verifies the impact of causality between the variables. (Stephen, 2020, p. 01)

When the variables are non-stationary, non-integrated, or integrated at different orders, the traditional Granger causality test becomes ineffective. In such cases, the Toda-Yamamoto Causality Test (1995), based on the Wald statistic "W", is used. This test is distributed according to the chi-square distribution. The null hypothesis suggests no causality between the variables (Prob $\chi^2 > 5\%$) (Kuma, 2018, p. 32).

The results of the causality test between variables can be summarized in the following table:

Table 7: results of the causality test according to Toda-Yamamoto.

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 08/30/23 Time: 18:49
Sample: 1990 2021
Included observations: 30

Dependent variable: LGDP

Excluded	Chi-sq	df	Prob.
LLTR	1.196016	2	0.5499
All	1.196016	2	0.5499

Dependent variable: LLTR

Excluded	Chi-sq	df	Prob.
LGDP	2.372630	2	0.3053
All	2.372630	2	0.3053

***The source**: Prepared by the researchers based on the outputs from Eviews 13 softwar.*

The Toda-Yamamoto causality test in the table shows that there is no causality between the variables since the probabilities are greater than the 5% significance level. Thus, we accept the null hypothesis, which means there is no bidirectional causality between logistics transport and GDP. This implies that the volume of goods in Algeria does not significantly impact economic growth, and vice versa. Therefore, it suggests that the government's policy does not place significant importance on developing its logistics services.

5 Conclusion:

The aim of our study was to examine the relationship between logistics transport and economic growth in Algeria during the period 1990-2021. Based on the analysis of time series data using the ARDL cointegration methodology, the results showed a positive and significant impact of

logistics transport on economic growth in both the short and long run. An increase of 1% in logistics transport leads to a 3.014% acceleration in economic growth in the long term. Short-term deviations are corrected by 24.78% in the long term, indicating that the development of goods movement can enhance economic growth, as Algeria is located among highly important trade routes. The study also confirmed that there is no causality between logistics transport and GDP, meaning there is no directional impact between them.

It's worth noting that the volume of goods used as a logistics indicator in our research is just one of the available indicators, and this should be taken into consideration. However, this doesn't negate the analysis results that in the long term, the volume of goods contributes to boosting economic growth in Algeria. Based on these findings, we propose some recommendations:

- The need to develop logistics services, update equipment, and increase infrastructure construction, as they play a role in connecting production and consumption, both domestically and internationally, in urban and rural areas, thereby enhancing economic growth;
- Building efficient and smart logistics network systems to improve the efficiency of goods flow and the level of logistics services, which effectively reduces the goods transit pace, crossing costs, and saves transportation time;
- The need for performance and impact measurement systems capable of supporting strategic investment decisions;
- Developing railway infrastructure and enhancing the quality of ports, as well as promoting and liberalizing air freight, ensuring an increase in the logistics performance index and competitiveness;
- Implementing effective and realistic economic policies, with political stability ensured for the country.

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