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RESEARCH ARTICLE

A Study of The Long-Term Causal Relationship between Agricultural Exports and Gross Domestic Product in Algeria for the Period (1999–2022), Using the Toda–Yamamoto approch

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Keywords Agricultural exports; Toda–Yamamoto approach; gross domestic product.

Abstract

The objective of this research paper is to examine the long-term causal relationship between agricultural exports and gross domestic product in Algeria for the period 1999–2022, using the Toda–Yamamoto methodology. The study finds the existence of a unidirectional long-term causal relationship running from agricultural exports to gross domestic product in Algeria. This result reflects the strategic role of agricultural exports in enhancing the productive capacity of the economy by expanding external markets and increasing foreign currency inflows, which contribute to financing domestic investments and improving the level of technology and productivity in the agricultural sector. This implies that sustained changes in the level of agricultural exports constitute a guiding factor and a key driver of long-term economic growth. Agriculture is considered a strategic sector, particularly as Algeria possesses natural and human resources that qualify it to be one of the drivers of economic diversification outside the hydrocarbons sector. It is also a source of food security and employment generation. Algeria has adopted agricultural programs and policies aimed at increasing domestic production and improving productivity; however, the impact of these efforts has not been strongly reflected in the level of exports, which have remained largely oriented toward the domestic market. Moreover, the structure of Algerian agricultural exports still mainly relies

on raw or semi-processed products such as dates, fruits and vegetables, and oils, which reduces their value added and limits their competitiveness in global markets.

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Introduction:

In addition, the agricultural export sector faces a set of structural and logistical challenges, most notably limited storage and refrigeration capacities, weak external marketing networks, fluctuations in production levels due to climatic factors, and high transportation and shipping costs. All of this has resulted in the relatively weak contribution of agricultural exports to total national exports, which in most years accounts for less than 5% of total exports, despite a relative increase in some products with external demand.

Accordingly, the reality of agricultural exports in Algeria raises a central issue regarding the extent to which the agricultural sector can shift from the role of "production oriented toward domestic consumption" to that of an "export-oriented productive sector" capable of supporting economic growth and reducing dependence on hydrocarbons.

In light of the above, the research problem is embodied in the following main question: *Is there a causal relationship between agricultural exports and gross domestic product in Algeria?*

Study Hypotheses: To address the stated problem, the following hypothesis is formulated:

- **There exists a long-term causal relationship between agricultural exports and gross domestic product in Algeria**.؟

Importance of the Study: The importance of this research lies in examining the long-term causal relationship between agricultural exports and gross domestic product, given that the development of agricultural exports reflects the competitiveness of agricultural products in international markets, and that the contribution of agricultural exports to GDP is an indicator that explains their ability to contribute to economic growth.

Objectives of the Study: The objectives of the study are as follows:

- To highlight the extent to which agricultural exports contribute to supporting gross domestic product.
- To determine the direction of causality between agricultural exports and gross domestic product using the Toda–Yamamoto test, in order to identify:
    - whether agricultural exports explain the growth of gross domestic product, or whether gross domestic product drives an increase in agricultural exports.

Methodology Used: The descriptive–analytical approach is adopted to clarify the theoretical framework of the relationship between agricultural exports and gross domestic product, while the quantitative approach is used to determine the direction of the relationship between the study variables.

Previous Studies: There are numerous studies that have examined the relationship between agricultural exports and gross domestic product. Among the most important of these studies are the following:

- **Study by Věra Bečvářová and Nahanga Verter (2016):** This paper aims to examine the impact of agricultural exports on economic growth in Nigeria using Ordinary Least Squares (OLS), Granger causality, the Impulse Response Function, and Variance Decomposition analysis. The regression results and Granger causality test reveal a positive relationship supporting the hypothesis of export-led economic growth driven by agricultural exports. However, the results also indicate an inverse relationship between the degree of agricultural openness and economic growth, suggesting that openness may not always be beneficial to the Nigerian economy. Furthermore, the impulse response function shows upward and downward fluctuations in the impact of agricultural exports on economic growth in Nigeria, while the variance decomposition analysis demonstrates that shocks to agricultural exports contribute to long-term fluctuations in economic growth (Alimat, Battaineh, 2019).

- **Study by Hala A. Alattabi, Basim H. AlBadri, and Saad A. AlBadawi:** This study aims to examine the causal relationship between agricultural exports and agricultural growth in Iraq using annual data for the period 1990–2017 within a Vector Autoregression (VAR) framework. The degree of integration of the variables was determined using unit root tests. The results indicate that the variables are non-stationary at their levels but become stationary at first differences, and that there is no causal relationship in either direction between agricultural exports and agricultural growth in Iraq.

- **Study by Ankit Chhikara and Laurel Pasricha:** This research aims to study the causal relationship between agricultural exports and economic growth over the period 1992–1993 to 2018–2019. Gross Domestic Product (GDP) was used as a proxy for economic growth. The study employed the Johansen cointegration test to determine whether a long-run relationship exists between the two study variables—agricultural exports and economic growth. A Vector Error Correction Model (VECM) was used to identify whether there is short-run or long-run causality between them. The results show the existence of short-run causality between the variables when GDP is the independent variable and agricultural exports are the dependent variable, but not the opposite. Granger causality tests also indicate a unidirectional causal relationship running from GDP to agricultural product exports (Bbaale, & Mutenyo, 2011).

- **Study by Paul-Alfred Kouakou Kouakou:** This study aims to evaluate the tangible effects of agricultural and non-agricultural exports on economic growth in Côte d'Ivoire. The study relies on data from the World Bank (World Development Indicators) and the Central Bank of West African States for the period 1985–2015. Data analysis required the use of the Autoregressive Distributed Lag (ARDL) model. The results show that agricultural exports have positive and statistically significant effects on GDP, although these effects tend to weaken over the long run. Non-agricultural exports have a positive but statistically insignificant effect on economic growth in the short run; however, they improve the country's economic performance in the long run. The study also finds that gross fixed capital formation stimulates wealth creation, while trade openness negatively affects economic development.

2. The Nature of Exports and Their Role in Achieving Economic Development: Exports play an important role in increasing income and maximizing the value of gross domestic product, thereby contributing to overall economic development.

2.1 Concept of Exports: There are several definitions of exports, which can be summarized as follows: Countries around the world, regardless of their capabilities and resources, seek to market part of their products to other countries in exchange for importing the goods and services they need. The export sector is considered one of the important sectors upon which countries increasingly rely in order to achieve a positive trade balance (Ghribi, 2014).

- **At the firm level:** Exports are the process of disposing of the economic surplus generated by the firm to external agents.

- **At the national level:** Exports are the process of disposing of the economic surplus generated by a country to countries that suffer from production shortages; they involve the crossing of goods and services beyond national borders.

- **At the international level:** Exports are a means of achieving economic welfare for any country, used to face competition and penetrate foreign markets. Mastery of export techniques leads to the prosperity of a country's external economic relations[i].

2.2 Importance of Exports: The importance of exports is reflected in their ability to mobilize public revenues in foreign currency, create new employment opportunities, correct balance of payments deficits, attract domestic and foreign private investment, and ultimately achieve good economic growth rates.

- **Job creation:** The export sector is a primary absorber of new labor. This has been confirmed by the experiences of many countries. East Asian countries such as Japan, Hong Kong, Taiwan, Indonesia, Malaysia, and Thailand have succeeded in creating new jobs and increasing their growth rates through export-oriented strategies, which helped reduce unemployment levels.

- **Correcting balance of payments deficits:** Exports are one of the main sources of foreign currency inflows, directly affecting financial balance, monetary stability, the value of the national currency, and exchange rates. Exports play a direct and essential role in addressing imbalances in the balance of payments by correcting trade balance deficits.

- **Attracting domestic and foreign investment:** Investment is considered a key driver of successful export processes, as demonstrated by many successful international experiences. Foreign investment brings modern technology, expertise, links to global markets, product diversification, and quality improvement[ii].

2.3 Role of Exports in Economic Development: Foreign trade plays a crucial role in financing economic development, especially in developing countries, due to the insufficiency of domestic resources to finance development. This importance can be summarized as follows:

- **Expanding the economic base:** The narrowness of the domestic market, due to weak purchasing power, is one of the causes of underdevelopment and limited economic activity. Therefore, governments seek to expand domestic markets through various means such as income redistribution and tax reductions. On the other hand, global markets represent an outlet for increased domestic production and are thus a key factor in expanding the economic base[iii].

- **Providing capital:** Foreign trade contributes to the provision of productive capital (such as machinery and equipment) as well as semi-finished products used in establishing projects, which leads to an increase in national income.

- **Impact of economic fluctuations on the national economy:** It is observed that developing countries export a very limited number of goods, often concentrated in services and agricultural products. Developing countries also rely heavily in their exports on raw materials such as oil or agricultural products[iv].

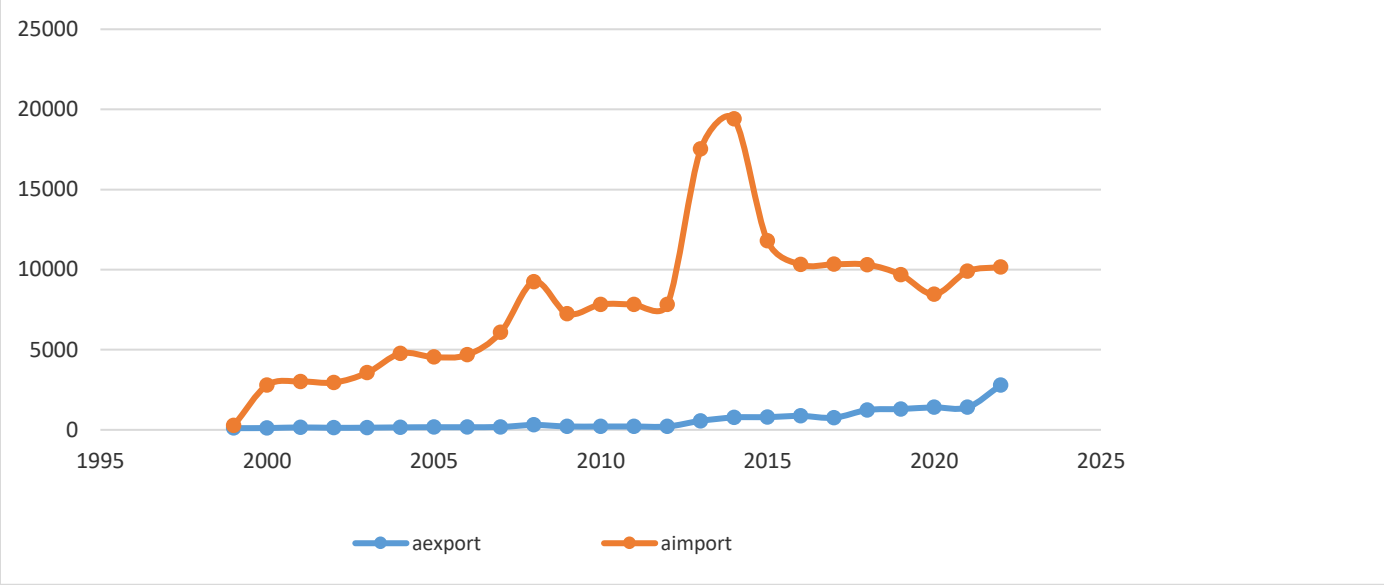
3. The Reality of Agricultural Exports in Algeria and Their Indicators: The agricultural sector is one of the vital sectors in the Algerian economy, as it constitutes an important pillar of food security, provides raw materials for many agro-industrial activities, and represents a significant source of employment and rural development. Despite the reforms and development programs implemented in the sector over recent decades, its contribution to total exports remains below the desired level. Therefore, economic diversification and the promotion of growth outside the hydrocarbons sector—particularly agricultural exports—have become imperative. The agricultural sector is considered a strategic alternative to hydrocarbons and a key driver of economic development, especially since Algeria possesses

vast potential that qualifies it to be an important source of foreign currency earnings. Consequently, studying this reality, analyzing its evolution, and identifying the constraints to its growth constitute an essential step toward understanding the prospects for developing Algeria's external agricultural trade (Sharma, & Panagiotidis, 2005).

3.1 Development of Agricultural Exports in Algeria (1999–2022): Agriculture is among the most important sectors in which Algeria seeks to invest in the coming period as a strategic alternative to hydrocarbon revenues, particularly after the sharp decline in oil prices following the crisis that affected global markets starting in mid-2014. Despite this orientation toward supporting and developing the agricultural sector, the value of agricultural exports remains, at present, modest and does not yet reflect the scale of the natural and human potential that Algeria possesses in this field.

- **Development of Agricultural Exports and Imports in Algeria (1999–2022):** Studying agricultural exports and imports is of great importance in understanding their trajectory over time. The following figure illustrates this development.

Figure 01: Development of agricultural exports and imports during the period 1999–2022



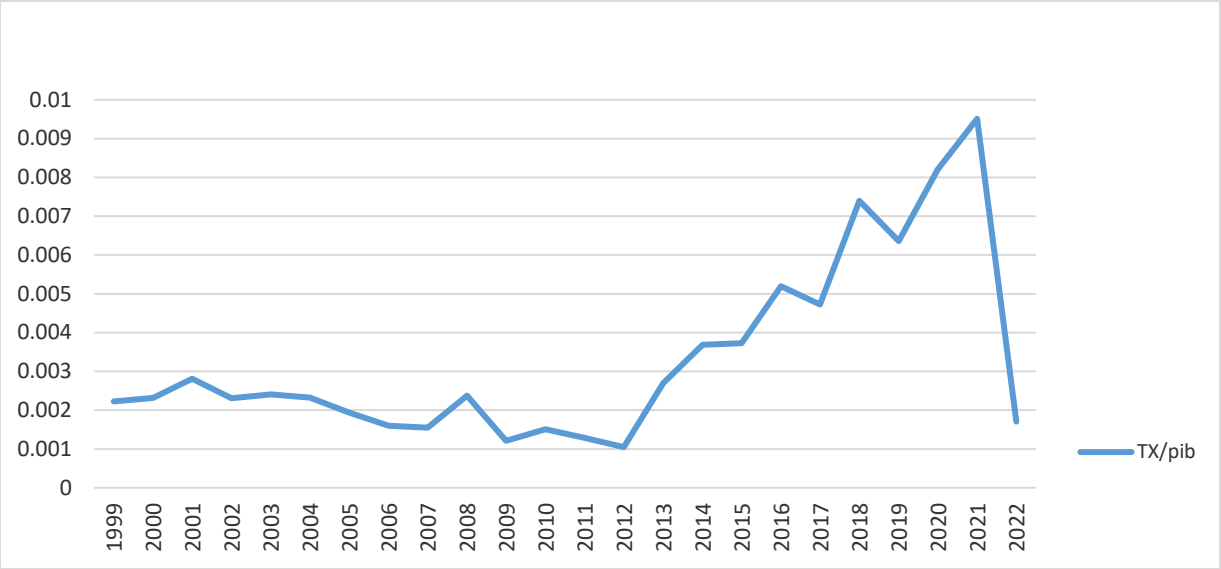
Source: Prepared by the authors based on the Arab Organization for Agricultural Development

From Figure 01, it can be observed that the agricultural sector in Algeria experienced a noticeable improvement in exports during the period from 1999 to 2022; however, this improvement remained limited compared to the significant increase in agricultural imports, which maintained a widening deficit in the agricultural trade balance. Agricultural exports increased from approximately USD 105 million in 1999 to USD 2.79 billion in 2022, as a result of higher exports of dates, some fruits and vegetables, and improved performance of agro-food processing industries in recent years. Despite this growth, agricultural imports remained at high levels, exceeding USD 10 billion annually during most of the period, with record values surpassing USD 17 billion in 2013–2014. This reflects the continued dependence of the Algerian economy on external sources for basic food commodities, especially cereals, milk, sugar, and vegetable oils[v]. The low coverage ratio of agricultural imports by agricultural exports indicates that agricultural imports absorb the largest share of revenues generated from hydrocarbons. This development shows that efforts to promote agricultural exports have not been sufficient to offset the sharp rise in imports, confirming the existence of

a structural imbalance between domestic supply and internal demand and highlighting the need to strengthen national production, diversify exports, and improve the competitiveness of Algerian agricultural products.

3.2 Contribution of Agricultural Exports to Gross Domestic Product: Agricultural exports are considered one of the fundamental components of economic activity, as they represent an important source of foreign income and a means of diversifying the productive base away from the hydrocarbons sector.

Figure 02: Percentage contribution of agricultural exports to GDP in Algeria during the period 1999–2022

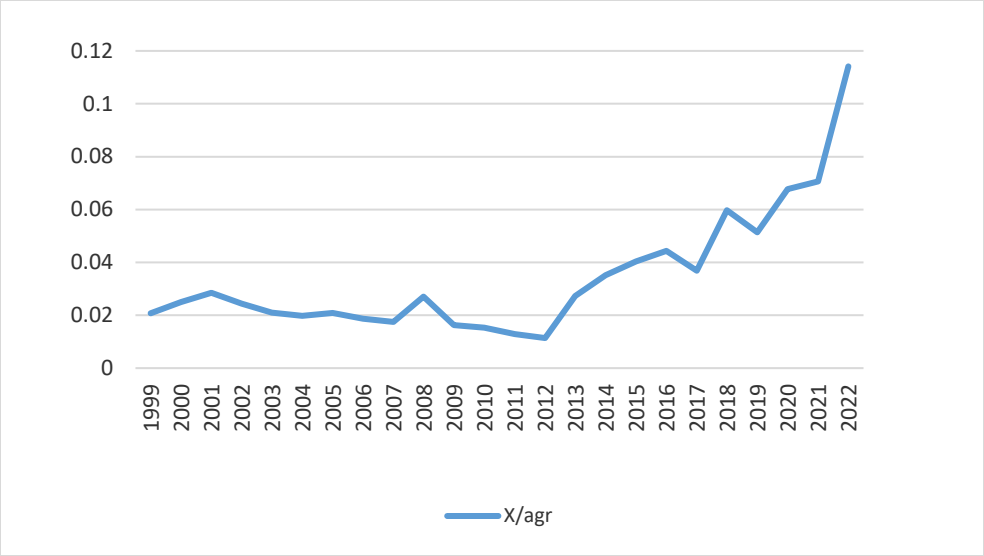


Source: Prepared by the authors based on the Arab Organization for Agricultural Development and World Bank data.

The contribution of agricultural exports to GDP is one of the key indicators for measuring the ability of the agricultural sector to create value added and contribute to external economic growth. Data for recent years indicate that the contribution of agricultural exports to GDP remains very weak, generally ranging between only 0.1% and 1%. These levels do not reflect the scale of the natural and productive potential available in Algeria. This weak contribution is attributable to several factors, including the limited range of exportable products, the concentration of exports in a few primary commodities such as dates, and the declining competitiveness of agricultural products due to quality, marketing, and agro-processing constraints. Although some improvement was recorded during the period 2015–2021, this increase remains insufficient to raise the sector's real weight within GDP, which calls for the adoption of broader production diversification policies and the enhancement of value added in order to increase the contribution of agricultural exports to the national economy.

3.3 Contribution of Agricultural Exports to Agricultural Production: The share of agricultural exports in agricultural production can be illustrated through the following figure:

Figure 03: Percentage contribution of agricultural exports to agricultural production



Source: Prepared by the authors based on the Arab Organization for Agricultural Development and World Bank data.

From the figure, it can be observed that the contribution of agricultural exports to agricultural output in Algeria during the period 1999–2022 was, for a long time, primarily oriented toward meeting domestic demand, as the contribution ratio did not exceed 3% before 2015. However, in recent years a noticeable increase has been recorded, with the ratio reaching 11.4% in 2022, indicating an improvement in the sector's ability to generate an exportable surplus. This improvement is attributed to the expansion of exports of dates, olive oil, and certain fruits and vegetables, in addition to the development of agro-food processing industries and the targeting of new markets. Nevertheless, the overall contribution remains weak, which calls for the adoption of integrated policies to enhance the value added of agricultural products and improve the sector's competitiveness in international markets.

4. Measuring the Relationship between Agricultural Exports and Gross Domestic Product in Algeria According to the Toda–Yamamoto Methodology: This study examines the long-term causal relationship between agricultural exports and gross domestic product in Algeria for the period 1999–2022, using the Toda–Yamamoto causality test.

4.1 Toda–Yamamoto Methodology: The long-term causality test developed by Toda and Yamamoto (1995) is considered one of the modern methods used to measure causal relationships between economic variables in time series models, as a robust alternative to Granger causality tests in the presence of heterogeneity in the stationarity levels of variables.

The Toda–Yamamoto approach is characterized by allowing causality testing without the prior need to verify the existence of cointegration between variables. The methodology is based on estimating an augmented Vector Autoregression (Augmented VAR) model and applying a modified Wald (MWald) test through the following steps[vi]:

- Determining the maximum order of integration of the variables (dmax).
- Estimating a VAR model with the optimal number of lags (k) according to information criteria (AIC, SC, etc.).
- Adding dmax lags in levels (not in differences) to obtain a VAR model of order (k + dmax).

- Conducting the causality test by applying the Wald test to the first (k) lags in the augmented VAR model.

The purpose of adding extra lags is to neutralize the effects of non-stationarity or heterogeneity among variables, thereby ensuring an asymptotic chi-square distribution for the Wald test, even if the time series are not stationary at the same order.

This methodology was developed to address the limitations of the Granger[vii] causality test, which relies on:

- The requirement that all variables be stationary or cointegrated.
- The possibility of specification errors if the order of integration is incorrectly chosen.
- The loss of information resulting from transforming time series into first or second differences.

Accordingly, the Toda–Yamamoto (TY) methodology provides a solution that allows causality testing directly in levels, without transforming the series and without the need to estimate a Vector Error Correction Model (VECM).

The causal relationship test between two time series Xt and Yt according to the Toda–Yamamoto concept, is defined by the following model[viii]:

$$\gamma t = \beta_0 + \sum_{i=1}^{k} \beta_{1i}\gamma_{t-i} + \sum_{j=k+1}^{k+dmax} b_{2i}\, y_{t-j} + \sum_{i=1}^{k} Q_{1i}\, X_{t-1} + \sum_{j=k+1}^{k+dmax} Q_{2i}\, X_{t-j} + \varepsilon_{1t}$$

$$xt = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} x_{t-i} + \sum_{j=k+1}^{k+dmax} \alpha_{2i}\, x_{t-j} + \sum_{i=1}^{k} \delta_{1i}\, y_{t-i} + \sum_{j=k+1}^{k+dmax} \delta_{2j}\, y_{t-j} + \varepsilon_{2t}$$

Then, the Wald test is conducted only on the coefficients of the lags from 1 to K

$$H0: \beta 1 = \beta 2 = \cdots = \beta k = 0$$

If the null hypothesis H0 is rejected, this indicates the existence of a causal relationship from X to Y, according to the Toda–Yamamoto approach.

Conditions for Applying the Toda–Yamamoto Methodology:

- The variables may be integrated of order I(0), I(1), or I(2).
- The absence of cointegration is not a prerequisite.
- The estimated VAR model must be stable and well specified.
- It is necessary to determine:
  - The maximum order of integration dmaxd;
  - The optimal number of lags (k);
  - Then construct a VAR model of order k+dmaxk

4.2 Description of the Study Variables: Based on previous studies, a set of variables that may be related to agricultural exports and gross domestic product was selected. The following table presents the study variables and their data sources:

Table 01: Description of the study variables

Symbol	Variable Name	Source	Nature of the Variable
Gdp_i	GDP per capita	World Bank	Dependent variable
Aexport	Agricultural exports	Arab Organization for Agricultural Development Yearbook	Independent variable
Tx	Real effective exchange rate	World Bank	Independent variable
Ato1	Agricultural trade openness (agricultural exports + agricultural imports) / GDP	Arab Organization for Agricultural Development Yearbook	Independent variable

Source: Prepared by the authors.

4.3 Stationarity Analysis of Time Series: Testing the stationarity of time series

Before proceeding with the study of the long-term causal relationship between agricultural exports and gross domestic product, it is necessary to examine the stationarity of the time series using the Augmented Dickey–Fuller (ADF) unit root test. The following table presents the results.

Table 02: Results of the unit root test using the ADF test ADF unit root test results

2nd diff			1st diff			Level			varaibles
None	C	T and C	None	C	T and C	None	C	T and C	
/	/	/				-1.7626	-3.4437***	-4.3146	GDP
/	/	/	-4.8419***	-5.2321***	*** -5.3204	-1.8505	-2.4910	-2.6558	Tx
-4.662***	-4.63***	-4.6456***	-1.8139	2.5153-	-3.5601	3.0028	0.3825	2.7069	Aexport
/	/	/	/	/	/	-0.5736	-3.3247***	-3.3668	Ato1

Source: Prepared by the authors based on EViews 12 outputs.

(***) indicates acceptance of the alternative hypothesis (H1), which states that there is no unit root; that is, the series is stationary at the 5% significance level.

The results of the unit root test indicate that **GDP** and **Ato1** are stationary at level, i.e., integrated of order I(0), while the **real effective exchange rate** is stationary at the first difference, i.e., I(1) and **agricultural exports** are stationary at the second difference, i.e., I(2). Accordingly, the maximum order of integration is 2=d_{max}

4.4 Determination of the Optimal Lag Lengths: The optimal lag lengths are determined by relying on the Vector Autoregression (VAR) model, using the information criteria AIC, SC, HQ, FPE, and LR. The results are as follows:

Table 03: Results of determining the optimal lag lengths

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-350.8510	NA	5.59e+09	33.79533	33.99429	33.83851
1	-314.8526	54.85459*	8.63e+08	31.89073	32.88551	32.10662
2	-293.2329	24.70823	6.17e+08	31.35552	33.14613	31.74413
3	-265.8361	20.87376	3.79e+08*	30.27011*	32.85654*	30.83143*

Source: Prepared by the authors based on EViews 12 outputs

The results shown in Table 03 indicate that the optimal lag length for the estimated VAR model, according to the SC criterion, is p=3. Accordingly, k=5, which satisfies the required condition $K \geq d_{max}$

4.5 Results of the Long-Run Causality Test Using the Toda–Yamamoto Method: After determining the maximum order of integration of the study variables dmaxd, identifying the optimal lag length (k), and estimating the augmented VAR model VAR(k+dmax), where the augmented model is VAR(2+3), the long-run causal relationship is tested using the Toda–Yamamoto (TY) causality test. The results are summarized in the following table:

Table 04: Results of the Toda–Yamamoto test

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 12/07/25 Time: 00:23
Sample: 1999 2022
Included observations: 19

Dependent variable: AEXPORT

Excluded	Chi-sq	df	Prob.
GDP_I	7.563197	2	0.0228
ATO1	2.834212	2	0.2424
TX	1.548734	2	0.4610
All	19.30711	6	0.0037

Dependent variable: ATO1

Excluded	Chi-sq	df	Prob.
GDP_I	39.25167	3	0.0000
AEXPORT	20.73851	3	0.0001
TX	47.63932	3	0.0000
All	90.93358	9	0.0000

Source: Prepared by the authors based on EViews 12 outputs.

The test results indicate the following:

Existence of a unidirectional long-run causal relationship running from agricultural exports to gross domestic product in Algeria. This implies that sustained changes in the level of agricultural exports constitute a guiding factor and a key driver of long-term economic growth. An increase in the value of agricultural exports reflects improvements in domestic production and quality, leads to inflows of foreign currency, enhances financing capacities, and stimulates investment in agricultural activities and related sectors such as agro-food industries and logistics services. Consequently, agricultural exports represent an important explanatory variable for gross domestic product in the long run.

Existence of a unidirectional causal relationship from agricultural trade openness to gross domestic product. This indicates that policies and measures that enhance the integration of the agricultural sector into international trade—whether through reducing tariff barriers, improving terms of trade, or developing the structure of agricultural exports and imports—contribute to promoting economic growth. Accordingly, strengthening agricultural trade openness represents a key instrument for stimulating economic growth, and expanding the external integration of the agricultural sector is a necessary step to increase agriculture's contribution to GDP in the long run.

Existence of a unidirectional causal relationship from agricultural trade openness to agricultural exports. This suggests that the degree of integration of the agricultural sector into international trade is a guiding and influential factor in determining the volume and level of agricultural exports. Improvements in trade openness—whether through trade liberalization, reduction of tariff and non-tariff barriers, or the strengthening of trade partnerships—lead to increased agricultural export flows in the long run.

Existence of a unidirectional causal relationship running from agricultural trade openness to the real effective exchange rate in Algeria. This indicates that changes in the degree of openness of the agricultural sector to foreign trade constitute a significant factor influencing movements in the real effective exchange rate.

Conclusion:

Agricultural exports constitute one of the fundamental components of economic activity, as they represent a source of foreign currency and play a role in stimulating production and creating employment opportunities. The results show that:

- The relationship between agricultural exports and gross domestic product is positive and significant in the long run, as the development of exports contributes to supporting economic growth by increasing value added in the agricultural sector and improving the balance of payments.

- The results of the causality test based on the Toda–Yamamoto methodology reveal the existence of a unidirectional long-run causal relationship running from agricultural exports to gross domestic product (GDP), with no reverse causality in the opposite direction. This indicates that the development of agricultural exports constitutes a stimulating factor for long-term economic growth.

- The results also indicate the existence of a unidirectional causal relationship from agricultural trade openness to agricultural exports. This means that changes in the degree of trade openness in the agricultural sector act as an explanatory and driving factor for changes in the volume of agricultural exports, without agricultural exports being a direct cause of changes in the level of agricultural trade openness.

- The causality test results further indicate the existence of a unidirectional causal relationship running from agricultural exports to the real effective exchange rate (REER), while no causal relationship is recorded in the opposite direction. This implies that changes in the volume of agricultural exports directly affect developments in the real effective exchange rate through their impact on foreign currency inflows,

improvements in the agricultural trade balance, and the resulting pressures on the value of the domestic currency.

Ethical Considerations

This study is based exclusively on secondary data obtained from publicly available national and international statistical sources. No human participants, personal data, surveys, or experiments were involved. Therefore, ethical approval from an institutional review board was not required. The research was conducted in accordance with accepted academic standards of integrity, transparency, and responsible data use.

Author Contributions

- Rekabi Saddam: Conceptualization, methodology, econometric analysis, data interpretation, and drafting of the original manuscript.
- Azzazi Farida: Literature review, theoretical framework development, results discussion, and critical revision of the manuscript.
- Haouchine Ibtissem: Data collection, validation of econometric results, and contribution to policy implications.
- Bouabdellah Mohammed Amine: Editing, formatting, and technical support, including proofreading and consistency checks.

All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest. The authors declare that there is no conflict of interest regarding the publication of this paper.

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