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The Impact of the Real Effective Exchange Rate on Algeria's Non-Hydrocarbon Exports: Evidence from the Autoregressive Distributed Lag (ARDL) Model, 1990–2023

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Abstract:

This study examines the impact of the Real Effective Exchange Rate (REER) on non – hydrocarbon exports in Algeria (1990-2023), controlling for crude oil prices and trade openness using the ARDL bounds testing approach. Empirical findings confirm a long-run cointegrating relationship at the 1% significance level. Long-run results reveal a statistically significant negative impact of REER on non-oil exports, a positive effect of oil prices operating via public investment channels, and a strong negative impact of trade openness driven by non-productive consumer imports. In the short run, the Error Correction Term ECT is negative and highly significant, indicating a rapid annual adjustment speed of 99.24% toward equilibrium. The study recommends implementing a flexible exchange rate policy to preserve price competitiveness, rationalizing trade openness, and directing oil windfalls toward building a diversified productive base.

Keywords: Non-Hydrocarbon Exports, Real Effective Exchange Rate (REER), ARDL Model, Trade Openness, Oil Prices.

JEL Classification Codes : C22 ; F14; F31; Q43

1. INTRODUCTION

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Economic diversification and the promotion of exports outside traditional sectors constitute one of the greatest challenges facing developing nations and rentier economies. In this context, the Algerian economy strives to break free from its excessive dependence on the hydrocarbon sector, which has served for decades as the primary source of public revenues and foreign exchange, thereby leaving the economy continuously vulnerable to shocks and fluctuations in global oil prices.

Amid this developmental ambition, monetary policy and its exchange rate framework occupy a pivotal role in influencing economic performance and the components of foreign trade. The Real Effective Exchange Rate (REER) is considered the most critical benchmark index for the price competitiveness of national products in international markets, as its valuation directly impacts the prices of domestic goods denominated in foreign currencies as well as the cost of imported goods. Despite successive economic reforms and programs adopted by Algeria since the 1990s to promote non-oil exports, their contribution remains well below the available productive potential. This raises serious questions regarding competitive efficiency and the responsiveness of these exports to fluctuations in the real effective exchange rate and governing macroeconomic variables, such as global oil prices and the degree of trade openness.

Research Problem

Despite government incentives to promote non-oil exports in Algeria, their responsiveness to exchange rate dynamics and global market conditions remains limited. Accordingly, this study addresses the central question:

What is the impact of the Real Effective Exchange Rate (REER) on non-hydrocarbon exports in Algeria during 1990–2023?

To comprehensively address this central problem, it has been divided into the following two core sub-questions:

- Is there a long-run cointegrating relationship between the Real Effective Exchange Rate (REER) and non-hydrocarbon exports in Algeria, and what are its dynamic short- and long-run impacts on price competitiveness, including the speed of adjustment toward equilibrium?
- How, and to what extent, do global crude oil prices and the degree of trade openness influence non-hydrocarbon export performance in the Algerian economy?

Study Hypotheses

Based on international trade theory and the structural characteristics of the Algerian economy, the following two main hypotheses were formulated for econometric testing:

- H1 (First Hypothesis): There exists a statistically significant long-run cointegrating relationship between the study variables, where real effective exchange rate appreciation negatively impacts non-hydrocarbon exports by eroding price competitiveness.
- H2 (Second Hypothesis): Global oil prices and trade openness exert statistically significant long-run impacts on non-hydrocarbon exports, with oil prices operating positively through public investment channels and infrastructure funding.

Significance of the Study

The significance of this study stems from its dual academic and practical contribution: academically, it enriches the econometric literature on real exchange rate dynamics and non-oil export determinants in developing, oil-dependent economies using the modern ARDL bounds testing approach; practically, it provides Algerian monetary and trade policy decision-makers with robust empirical evidence to evaluate exchange rate effectiveness and formulate actionable, competitiveness-driven strategies for sustainable economic diversification.

Objectives of the Study

This study aims to empirically estimate the short- and long-run impacts of the Real Effective Exchange Rate (REER) on non-hydrocarbon exports in Algeria using the ARDL framework, and measure the speed of adjustment toward equilibrium via the Error Correction Model (ECM). Ultimately, it seeks to provide evidence-based policy recommendations to enhance price competitiveness and support national economic diversification efforts.

Research Methodology

To achieve the study's objectives, a descriptive-analytical approach is combined with an inductive quantitative method using time series econometrics for Algeria spanning the period 1990–2023. Specifically, the Autoregressive Distributed Lag (ARDL) bounds testing approach and Error Correction Model (ECM) are deployed to analyze short- and long-run dynamic relationships between the Real Effective Exchange Rate (REER) and non-hydrocarbon exports, complemented by standard diagnostic and structural stability tests to ensure model reliability.

2. Literature Review

The dynamic relationship between exchange rate volatility and non-hydrocarbon (non-oil) export performance has received extensive attention in economic literature, owing to its pivotal role in guiding economic diversification policies. Below, we review

the most prominent empirical studies addressing this topic, ordered chronologically from the most recent to the oldest, leading to the formulation of the research gap that underpins this study:

Among recent literature, **(Kumar & et al, 2025)** focused on Central, Eastern, and Southeastern European (CESEE) countries using a Panel ARDL model, highlighting that the Human Development Index (HDI) and Gross Domestic Product (GDP) growth are the primary drivers of export competitiveness, while emphasizing the positive impact of Foreign Direct Investment (FDI) and domestic credit in boosting productive capacity. In the context of oil-dependent rentier economies, **(Ashour, 2023)** made a notable contribution by analyzing the asymmetric impact of the Real Effective Exchange Rate (REER) on non-oil exports in Saudi Arabia. The study revealed a critical threshold of 136.08, beyond which exports contract by 1.22%. Furthermore, it demonstrated that positive shocks (currency appreciation) harm exports, whereas productive capacity and private credit stimulate them. These findings are reinforced by another study by **Ashour (n.d.)**, which employed Vector Error Correction Models (VECM), ARDL, and threshold regression to confirm the deterioration of Saudi non-oil exports past a specific threshold range, while underscoring the vital role of developmental goods imports.

In the Nigerian context, **(Aliyu & et al, 2023)** applied an ARDL model and established a statistically significant negative relationship between non-oil exports and exchange rates, real interest rates, and public debt, contrasted with a positive effect from tax revenue and money supply. This aligns with the conclusions of **(Nduka & et al, 2021)**, who confirmed that exchange rate policies and trade openness exerted a significant negative impact on Nigeria's non-oil export sector. On the other hand, **(Al Marzoqi & El Mahmah, 2021)** drew attention to the side effects of fiscal policies in Saudi Arabia, warning that increasing non-oil revenues (via taxes and fees) exerts downward pressure on private consumption and investment, potentially hindering export growth drivers.

Re-evaluating this macroeconomic relationship, (Mayer & Steingress, 2019)asserted that the impact of exchange rate fluctuations on aggregate exports becomes clearer when taking complex trade structures and pricing effects into account. In Nigeria, (Iwuoha & Awoke, 2019) implemented the Johansen cointegration and error correction methodology, highlighting a long-run negative impact of the real exchange rate on non-oil exports. Conversely, **(Elech & et al, 2016)** reached a somewhat different conclusion, demonstrating no causal relationship between Nigerian bank credit and export performance despite the existence of cointegration. On a global scale, **(Ahmed & et al, 2015)** introduced a crucial structural dimension; using cross-sectional data from 46 countries, they proved that participation in Global Value Chains (GVCs) reduces the

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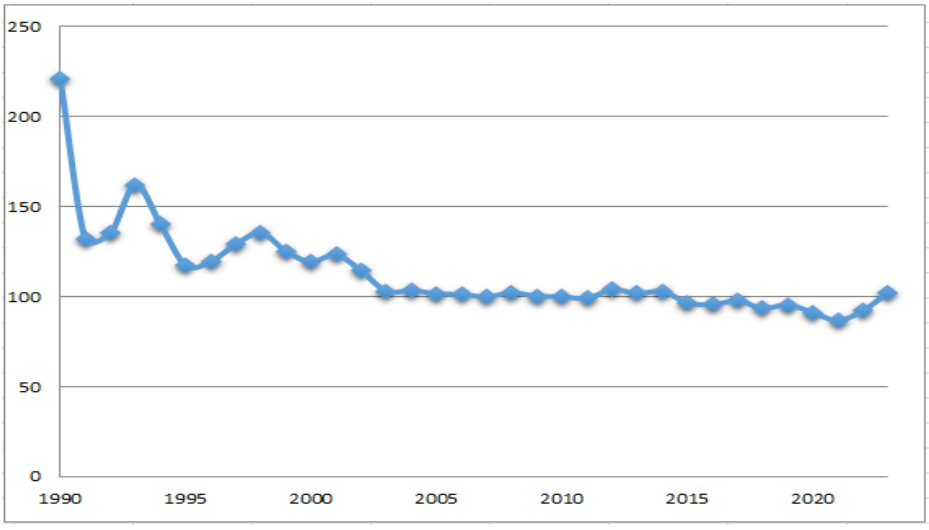
exchange rate elasticity of exports by 22% due to the high share of imported inputs in exported goods.

Several studies focused on the Azerbaijani economy, most notably **(Hasanov, 2012**), who utilized threshold models (TAR and M-TAR) to conclude that the adjustment path toward long-run equilibrium was symmetric, accompanied by a strong negative exchange rate effect. This was preceded by (**Hasanov & Samadova** , The impact of real exchange rate on non-oil exports: The case of Azerbaijan, 2010) who confirmed via a VECM model that sustained currency appreciation impedes export growth, showing that a 1% real currency appreciation leads to a 1.63% decline in exports in the long run. Also in Nigeria, (**Efobi & Osabuohien, 2011**) evaluated agricultural credit policies, finding a slight yet heterogeneous positive effect across crop types. In advanced economies, (**Berthou, 2008**) demonstrated through a Gravity Model that exchange rate volatility harms bilateral exports among OECD countries, particularly in high-value-added sectors. Finally, the IMF classic study by **(Lukonga, 1994**) established the foundational notion that exports in developing countries (such as Nigeria) depend on exchange-rate-driven price incentives, yet their responsiveness consistently faces supply-side structural constraints.

3. REER and Non-Hydrocarbon Export Dynamics in Algeria

3.1 REER Evolution in Algeria (1990–2023)

Fig.1. Dynamics of the Real Effective Exchange Rate in Algeria Over the Period 1990–2023



Source: Prepared by the authors using Excel

The Real Effective Exchange Rate (REER) index and its fluctuations reflect the evolution of price competitiveness of the national economy relative to its primary trading partners (with 2010 designated as the base year, 2010 = 100). Tracking the time series and graphical trajectory allows the evolutionary path of the Algerian Dinar's real effective exchange rate to be divided into five main phases:

Phase I (1990–1994): Structural Adjustment and Massive Devaluations

This period witnessed the highest levels of the index followed by a sharp decline, recording its historical peak in 1990 at **220.97**, before precipitously falling to **131.79** in 1991. It then rebounded temporarily to **162.13** in 1993 before dropping again to **139.99** in 1994. These sharp fluctuations are attributable to the monetary authorities' initial shift away from an administratively managed fixed exchange rate regime toward a managed float system, in compliance with Structural Adjustment Program (SAP) agreements with the International Monetary Fund (IMF). This phase entailed repeated official nominal devaluations of the Dinar to correct external imbalances and curb currency overvaluation.

Phase II (1995–2002): Transition and Shift Toward Moderate Stability

This phase was characterized by medium-term fluctuations within a range between **114.30** (in 2002) and **135.45** (in 1998). This path resulted from the combined effects of the Bank of Algeria's nominal exchange rate management policy and domestic inflation differentials relative to major trading partners, alongside global oil price volatility (particularly the 1998 oil price shock, which led to a temporary loss of competitiveness before financial inflows stabilized at the turn of the millennium).

Phase III (2003–2014): Relative Stability and Financial Opulence

This period was marked by remarkable and sustained stability in the $REER$ index around levels close to the base year, fluctuating between **99.87** (in 2007) and **103.91** (in 2012), and hitting **100.00** in the base year 2010. This stability was driven by the oil boom and surging crude prices, which enabled the Bank of Algeria to utilize substantial foreign currency reserves to absorb external shocks and control nominal exchange rate volatility. This stable monetary policy aimed to curb imported inflation and preserve purchasing power, although maintaining the real index at relatively high levels constrained improvements in the price competitiveness of non-oil sectors.

Phase IV (2015–2021): Oil Shock and Index Decline

The index entered a gradual and sustained downward path, declining from **102.92** in 2014 to reach its historical low in the series at **86.79** in 2021. This persistent fall was the result of a twin shock: the mid-2014 oil price collapse and the ramifications of the COVID-19 pandemic. Monetary authorities resorted to a gradual depreciation of the nominal Dinar to absorb trade and balance of payments deficits and safeguard foreign exchange reserves. The decline in $REER$ during this period lowered the real value of

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the Dinar, theoretically reflecting an improvement in the price competitiveness of domestic products.

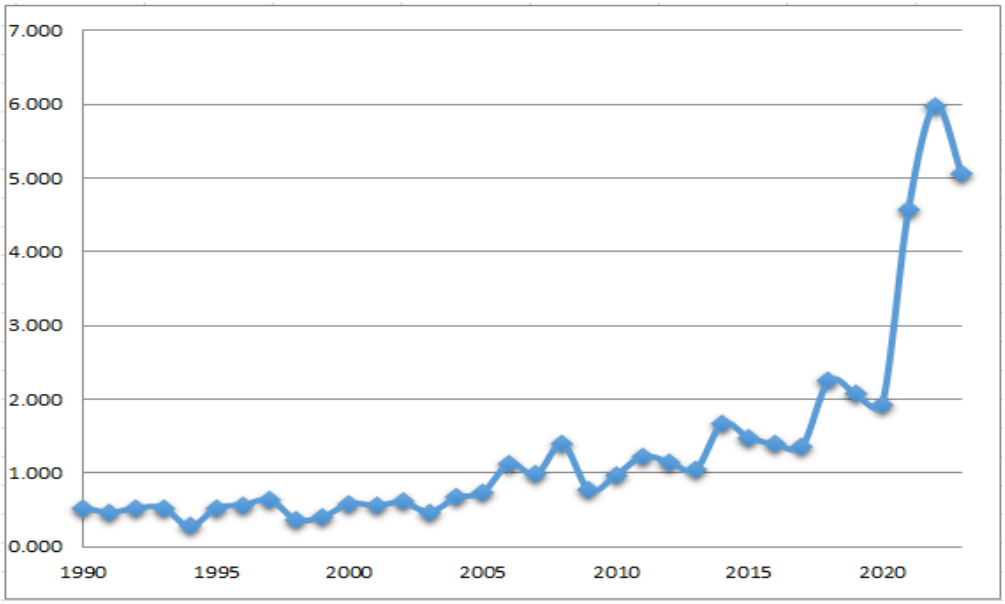
Phase V (2022–2023): Recovery and Partial Rebound

The index recorded a notable increase from **86.79** in 2021 to **92.33** in 2022, continuing its upward trajectory to reach **102.30** in 2023. This rapid recovery was driven by improved hydrocarbon prices in global markets following the 2022 geopolitical crises, alongside the Bank of Algeria's intervention to partially revalue the nominal Dinar to mitigate imported inflationary pressures arising from rising global raw material and food prices.

3.2 Analysis of Non-Hydrocarbon Exports Evolution in Algeria (1990–2023)

Non-Hydrocarbon Exports (NHX) serve as the focal dependent variable for measuring the success of economic diversification policies and evaluating the efficacy of exchange rate policy in stimulating non-oil productive sectors.

Fig.2. Dynamics of Non-Hydrocarbon Exports in Algeria Over the Period 1990–2023



Source: Prepared by the authors using Excel

The chronological tracking of the time series (in USD billions) reveals a prominent structural transformation, which can be divided into four distinct phases:

Phase I (1990–2005): Stagnation and Structural Marginality

This phase was characterized by severe weakness and stagnation, with non-hydrocarbon exports remaining confined below **$0.75 billion** for 16 consecutive years.

The series recorded its lowest value in 1994 at **$0.280 billion**, while reaching a phase peak of **$0.740 billion** in 2005. This limited performance reflects the fragility of the national productive base during the 1990s—a period marked by the Structural Adjustment Program alongside deep political and economic crises. Despite consecutive nominal currency devaluations during this decade, the export response from non-oil sectors remained extremely weak, illustrating the supply inelasticity of the national productive apparatus and a deficiency in non-price competitiveness, which extends beyond exchange rate adjustments alone.

Phase II (2006–2017): Fluctuations and Hesitant Growth (Surpassing the 1 Billion Threshold)

This period witnessed crossing the $1 billion threshold for the first time in 2006, recording **1.130 billion**, before rising to **1.395 billion** in 2008. It subsequently contracted to **0.771 billion** due to the 2009 Global Financial Crisis. Export values subsequently stabilized within the $1.00 to $1.66 billion range, reaching a phase peak of **1.667 billion** in 2014. This relative increase was linked to the general surge in global prices of raw materials and semi-finished products (such as fertilizers, chemicals, and petrochemical derivatives, which are often classified within non-oil exports). Nevertheless, the economy continued to exhibit symptoms of "Dutch Disease" driven by oil financial windfalls, with non-oil exports accounting for merely 3% to 5% of total exports.

Phase III (2018–2020): Initial Upswing and Pandemic Disruptions

Non-hydrocarbon exports surpassed the 2 billion mark for the first time in 2018, registering **2.249 billion**, and maintained comparable levels in 2019 at **2.079 billion**, before experiencing a minor decline in 2020 to **1.916 billion**. The improvement observed in 2018 and 2019 can be attributed to several new industrial projects entering the production and export stages (such as building materials like cement, iron and steel inputs, and fertilizers). Meanwhile, the contraction recorded in 2020 was entirely due to global supply chain disruptions and restrictions resulting from the COVID-19 pandemic. The improvement in non-hydrocarbon exports can be attributed to the implementation of the Economic Recovery Program and the Economic Growth Support Program (Djedi & Zobiri , 2025).

Phase IV (2021–2023): Unprecedented Structural Leap

The time series recorded exceptional and unprecedented growth; non-hydrocarbon exports surged from **1.916 billion** in 2020 to **4.579 billion** in 2021 (a growth rate exceeding 139%). Exports continued their upward trajectory to reach an **all-time**

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historical peak in 2022 at **5.980 billion** (approaching $6 billion), before undergoing a minor adjustment in 2023 to **5.059 billion**. Several compounding factors explain this historic surge:

- **Structural and Institutional Reforms:** The adoption of a proactive policy to encourage non-hydrocarbon exports by streamlining customs and financial procedures, alongside reactivating the Special Export Promotion Fund (FSPE).
- **Entry of Major Productive Capacity into Export Markets:** A significant expansion in the exports of fertilizers, urea, iron and steel (such as the Bellara and Tosyali industrial complexes), cement, and processed agricultural food products.
- **International Price Dynamics:** Surging global prices for fertilizers and steel during 2021 and 2022 following the post-pandemic economic recovery and the outbreak of the Russia-Ukraine conflict.
- **Exchange Rate Effect:** This growth intersects with the cumulative real depreciation observed in the Real Effective Exchange Rate (REER) during the period 2015–2021, offering preliminary evidence of the role of cumulative currency depreciation in enhancing the price competitiveness of domestic products once an export-oriented productive base was established.

4. RESULTS AND DISCUSSION

4.1 Empirical Model Specification and Data Sources

Econometric analysis serves as a fundamental pillar to verify theoretical propositions and test their validity within the context of developing and rentier economies. In this framework, this empirical section aims to model and measure the impact of variations in the Real Effective Exchange Rate (REER) while controlling for key structural macroeconomic variables, namely global crude oil prices (OIL) and trade openness (OPEN) on the performance of non-hydrocarbon exports (XNH) in Algeria.

To achieve optimal econometric estimation, the temporal scope of the study spans a 34-year period from **1990 to 2023** utilizing annual data.

To address the study's primary problem statement and test its underlying hypotheses, the non-hydrocarbon export function can be expressed in its general functional form as follows:

$$\mathrm{XNH}_t = f(REER_t, OIL_t, OPEN_t)$$

Where:

- **XNH:** The value of non-hydrocarbon exports, representing the dependent variable in the study (sourced from Bank of Algeria reports).
- **REER:** The Real Effective Exchange Rate, theoretically hypothesized to exert a negative effect on XNH.
- **OIL:** Global crude oil prices, theoretically expected to exert a negative effect on non-hydrocarbon exports.
- **OPEN:** Trade openness, theoretically expected to exert a positive effect on non-hydrocarbon exports.

Log-Linear Econometric Specification

For econometric estimation purposes, it is preferable to transform the economic function into a log-linear specification as follows:

$$\ln(\mathrm{XNH}_t) = \beta_0 + \beta_1 \ln(REER_t) + \beta_2 \ln(FDI_t) + \beta_3 \ln(OPEN_t) + \beta_4 \ln(GDP_t) + \varepsilon_t$$

Where:

- ln**:** Represents the natural logarithm operator applied to the variables.
- β_0**:** The constant intercept term.
- $\beta_1, \beta_2, \beta_3$ **:** The econometric parameters to be estimated, representing long-run elasticities.
- ε_t**:** The stochastic white-noise error term, assumed to be normally distributed with a mean of zero and constant variance.

Data Sources and Statistical Software

Empirical data for this study were compiled from official databases, retrieving the Real Effective Exchange Rate (REER) and trade openness (OPEN) from the World Bank, global crude oil prices (OIL) from the Organization of the Petroleum Exporting Countries (OPEC), and non-hydrocarbon export volumes (XNH) from the Bank of Algeria. All data processing, econometric estimation, and diagnostic testing were executed using EViews 12 software.

4. Stationarity Analysis :

Prior to estimating the econometric model, the stationarity properties of the underlying time series were evaluated to determine the order of integration for each variable and safeguard against spurious regression. For this purpose, the Augmented Dickey-Fuller ADF unit root test was applied.

Table 1. Augmented Dickey–Fuller (ADF) Unit Root Test Results

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	Level				1st Difference		
	lxnh	Lreer	loil	lopen	Dlxnh	Dloil	Dlopen
Trend and intercept	-3.25*	-6.6***	-2.06	-0.72	-6.22***	-5.48***	-7.16***
Intercept	-0;39	-4.6***	-1.10	-2.13	-7.62***	-5.58***	-6.61***
None	-0.53	-1.35	0.55	-0.48	-7.22***	-5.43***	-6.71***
Decision	H0	H1	H0	H0	H1	H1	H1

Source: Prepared by the researchers using EViews 12 software

Note: ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

H0: The time series contains a unit root (non-stationary).
H1: The time series does not contain a unit root (stationary).

Based on the table above, which presents the calculated Augmented Dickey-Fuller (ADF) test statistics alongside their associated statistical significance levels (for further details, see Appendices 2, 4, and 5), the empirical results indicate that the series for non-hydrocarbon exports (ln XNH), global crude oil prices (ln OIL), and trade openness (ln OPEN) are non-stationary in their levels. However, all three series achieve strict stationarity after first-differencing, confirming an order of integration of I(1). In contrast, the Real Effective Exchange Rate (ln REER) is stationary at level, I(0), around a deterministic trend. This mix of I(0) and I(1) variables -with no I(2) series-strictly satisfies the prerequisite for applying the ARDL bounds testing approach.

4.3 ARDL Bounds Test

Optimal Lag Selection

Based on the Akaike Information Criterion (AIC), which is highly efficient for small sample sizes, the top 20 estimated specifications were evaluated to select the optimal ARDL lag structure (see Figure 3 in the Appendix). The graphical evaluation confirms that the ARDL(1, 3, 3, 4) specification is optimal, achieving the lowest criterion value (AIC = -0.54). This model structure incorporates one lag for the dependent variable (ln XNH), three lags for two of the explanatory variables, and four for the third, thereby capturing temporal dynamics while preserving degrees of freedom.

Analysis of the Cointegration Bounds Test Results (F-Bounds Test)

Table 6. Bounds Test for Cointegration

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	6.855337	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Actual Sample Size	30	Finite Sample: n=30		
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

Source: Prepared by the researchers using EViews 12 software

Based on the table above, the F-bounds test results (k = 3) confirm the existence of a long-run cointegrating relationship among the study variables. The calculated F-statistic (6.855) decisively exceeds the upper bound critical value I(1) at both the 1\% level (5.966) and the 5\% level (4.306) for a sample size of n = 30. Consequently, the null hypothesis (H0) of no level relationship is rejected, establishing a statistically significant dynamic long-run equilibrium between non-hydrocarbon exports (ln XNH) and the explanatory variables (ln REER, ln OPEN, ln OIL). Methodologically, this finding provides the necessary justification to proceed to estimating the long-run parameters and the short-run Error Correction Model (ECM).

4.4 Long-Run Parameter Estimation Results and Statistical Significance Testing
4.4 Error Correction Model (ECM

Table 7. Estimated Long-Run Coefficients

Levels Equation Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LREER	-2.373087	0.685992	-3.459353	0.0035
LOIL	0.881021	0.166496	5.291529	0.0001
LOPEN	-4.081803	0.442342	-9.227710	0.0000
C	24.27334	3.085773	7.866212	0.0000
EC = LXNH - (-2.3731*LREER + 0.8810*LOIL -4.0818*LOPEN + 24.2733)				

Source: Prepared by the researchers using EViews 12 software

Based on the table above, the estimated long-run ARDL(1, 3, 3, 4) model reveals that all explanatory variables exert statistically significant impacts on non-hydrocarbon exports (ln XNH) at the 1% significance level ($p < 0.01$). Specifically, the Real Effective Exchange Rate (ln REER) displays a negative long-run elasticity ($\beta = -2.3731$, p = 0.0035), indicating that a 1% real appreciation of the Dinar reduces non-oil exports by 2.37%. This empirically validates the Marshall-Lerner condition, as currency

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appreciation erodes the price competitiveness of domestic goods in foreign markets. Conversely, global crude oil prices (ln OIL) exhibit a positive long-run effect ($\beta = 0.8810$, p = 0.0001), where a 1% price increase drives a 0.88% growth in non-oil exports; this reflects the revenue-driven public investment channel, where oil surpluses fund productive infrastructure and semi-petrochemical expansion. Finally, trade openness (ln OPEN) yields a strong negative coefficient ($\beta = -4.0818$, p = 0.0000), implying that a 1% expansion in openness contracts non-oil exports by 4.08%. Economically, this underscores severe import penetration and structural vulnerability, where opening the market exposed fragile domestic producers to intense foreign competition without generating export-led spillover effects.

Short-Run Parameter Estimation Results and Error Correction Model (ECM)

Table 8. Estimated Error Correction Model (ECM) and Short-Run Coefficients

ARDL Error Correction Regression
Dependent Variable: D(LXNH)
Selected Model: ARDL(1, 3, 3, 4)
Case 2: Restricted Constant and No Trend
Date: 07/21/26 Time: 18:16
Sample: 1990 2023
Included observations: 30

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LREER)	1.374750	0.619096	2.220574	0.0422
D(LREER(-1))	0.112319	0.698744	0.160744	0.8744
D(LREER(-2))	1.949112	0.606279	3.214874	0.0058
D(LOIL)	0.225734	0.177124	1.274441	0.2219
D(LOIL(-1))	-0.310079	0.198725	-1.560342	0.1395
D(LOIL(-2))	-0.436893	0.188362	-2.319434	0.0349
D(LOPEN)	1.389869	0.614868	2.260435	0.0391
D(LOPEN(-1))	3.580679	1.033299	3.465290	0.0035
D(LOPEN(-2))	3.809424	0.806978	4.720603	0.0003
D(LOPEN(-3))	1.679575	0.514902	3.261930	0.0053
CointEq(-1)*	-0.992385	0.150609	-6.589168	0.0000

R-squared	0.890945	Mean dependent var	0.075202
Adjusted R-squared	0.833548	S.D. dependent var	0.345461
S.E. of regression	0.140943	Akaike info criterion	-0.804346
Sum squared resid	0.377434	Schwarz criterion	-0.290574
Log likelihood	23.06519	Hannan-Quinn criter.	-0.639986
Durbin-Watson stat	2.533377		

Source: Prepared by the researchers using EViews 12 software

Based on the table above, the short-run dynamics and Error Correction Model (ECM) illuminate the temporal adjustment mechanism of non-hydrocarbon exports ($\Delta \ln(\text{XNH})$). Crucially, the error correction coefficient (CointEq_{t-1}) fulfills all econometric requirements: it is negative (-0.9924), statistically significant at the 1% level (t = -6.5892, p = 0.0000), and confirms a highly stable long-run equilibrium path. Its magnitude implies an exceptionally rapid speed of adjustment, where approximately 99.24% of short-run imbalances resulting from external shocks are corrected annually to revert back to the long-run equilibrium trajectory within a single year.In the short run, the Real Effective Exchange Rate ($\Delta \ln(\text{REER})$) displays statistically significant positive coefficients at both the contemporaneous level ($\beta = 1.3748$, p = 0.0422$) and the second lag ($\beta = 1.9491$, p = 0.0058). Economically, this initial positive response

captures the first phase of the J-curve effect, where contractual price rigidities boost nominal export values in foreign currencies before volume adjustments take effect. Conversely, global crude oil price changes ($\Delta\ln(\mathrm{OIL}_{t-1})$ exert a negative short-run impact at the second lag ($\beta = -0.4369$, p = 0.0349), reflecting temporary Dutch Disease spillover dynamics that reallocate domestic resources toward the booming hydrocarbon sector. Finally, trade openness (Δln (OPEN)) exhibits a strong, consistent positive effect across contemporaneous and all three lagged terms ($\beta_0 = 1.3899$, $\beta_1 = 3.5807$, $\beta_2 = 3.8094$, $\beta_3 = 1.6796$, all p < 0.05). Unlike its long-run contractive effect, trade openness in the short run acts as a catalyst by facilitating access to essential imported raw materials and intermediate inputs needed for domestic non-oil export production.

4.5 Diagnostic and Structural Stability Tests

To ensure the statistical reliability, econometric efficiency, and consistency of the estimated ARDL(1, 3, 3, 4) model, a battery of diagnostic and stability tests was performed. First, the Breusch-Godfrey LM test (Table 9 in the Appendix) confirms the absence of second-order serial correlation; the F-statistic (F(2, 13) = 2.8853, p = 0.0918) fails to reject the null hypothesis at the 5% level—a decision aligning with small-sample (n = 30) econometric literature favoring the F-statistic over asymptotic Chi-Square metrics. Second, the ARCH LM test (Table 10 in the Appendix) verifies error homoskedasticity, yielding non-significant statistics ($F = 1.6077, p = 0.2156$; Obs × $R^2 = 1.6297$, p = 0.2017). Third, the Jarque-Bera test (Figure 4 in the Appendix) establishes residual normality (JB = 0.6124, p = 0.7362), supported by near-symmetric skewness (-0.1066) and standard kurtosis (2.3333), thereby validating t- and F-test inferences. Finally, recursive residual tests (Figures 5 and 6 in the Appendix) demonstrate that both the CUSUM and CUSUMSQ plots remain strictly within the 5% critical boundaries across 2009–2023, confirming complete structural stability of short- and long-run parameters against structural shocks.

5. CONCLUSION

This study empirically investigated the dynamic impact of the Real Effective Exchange Rate (REER) on non-hydrocarbon exports (NHX) in Algeria over the period 1990–2023 within an Autoregressive Distributed Lag (ARDL) bounds testing framework. By integrating international trade theory with macro-econometric modeling alongside global crude oil prices (OIL) and trade openness (OPEN), the empirical results confirmed a mixed order of integration-with REER stationary at level I(0) and remaining variables integrated of order one I(1)-and established a statistically significant long-run cointegrating relationship (F = 6.855) at the 1% level for the optimal ARDL(1, 3, 3, 4)

specification. Subsequent diagnostic tests and recursive stability procedures (CUSUM and CUSUMSQ) verified that the estimated model is econometrically sound, homoskedastic, normally distributed, free from serial correlation, and structurally stable across time.

Econometrically, the long-run estimates demonstrate that real effective exchange rate appreciation negatively affects non-oil exports with a high elasticity of -2.3731, thereby empirically validating the Marshall-Lerner condition and highlighting price competitiveness as a crucial determinant of Algerian export performance. Conversely, global crude oil prices exert a positive long-run effect (+0.8810) operating through the revenue-driven public investment channel, whereas trade openness displays a pronounced long-run negative impact (-4.0818), reflecting severe import penetration and structural domestic fragility. In the short run, trade openness temporarily boosts non-oil exports by facilitating access to imported intermediate inputs, while REER exhibits initial positive dynamics consistent with the early phase of the J-curve effect. Notably, the error correction coefficient ($\mathrm{CointEq}_{t-1} = -0.9924$) reveals an extraordinarily fast speed of adjustment, where 99.24\% of short-run disequilibria and external shocks are corrected annually to restore long-run equilibrium within approximately one year.

To translate these empirical insights into actionable policy, Algerian economic authorities must pursue a three-pronged strategic framework. First, economic decision-makers should implement a managed, flexible exchange rate policy aligned with economic fundamentals to prevent real currency overvaluation and safeguard export price competitiveness. Second, policymakers need to restructure trade openness from consumer-driven import penetration toward productive openness that prioritizes technology transfer and capital inputs while providing targeted, temporary protection for emerging domestic export industries. Third, fiscal windfalls from high-oil-price cycles must be systematically channeled into productive infrastructure, modern logistics, manufacturing, and petrochemical processing rather than recurrent consumption, thereby building the structural foundation required for sustainable economic diversification.

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7. Appendices

Table 2. ADF Test Results for Non-Hydrocarbon Exports

Null Hypothesis: LXNH has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.256434	0.0913
Test critical values:	1% level	-4.262735	
	5% level	-3.552973	
	10% level	-3.209642	

Null Hypothesis: D(LXNH) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.232376	0.0001
Test critical values:	1% level	-4.284580	
	5% level	-3.562882	
	10% level	-3.215267	

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Null Hypothesis: LXNH has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.391336	0.8994
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

Null Hypothesis: D(LXNH) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.621746	0.0000
Test critical values:	1% level	-3.653730	
	5% level	-2.957110	
	10% level	-2.617434	

Null Hypothesis: LXNH has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.536148	0.4770
Test critical values:	1% level	-2.636901	
	5% level	-1.951332	
	10% level	-1.610747	

Null Hypothesis: D(LXNH) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.220189	0.0000
Test critical values:	1% level	-2.639210	
	5% level	-1.951687	
	10% level	-1.610579	

Source: Prepared by the researchers using EViews 12 software

Table 3. ADF Test Results for REER

Null Hypothesis: LREER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.654920	0.0000
Test critical values:	1% level	-4.262735	
	5% level	-3.552973	
	10% level	-3.209642	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LREER)
Method: Least Squares
Date: 07/29/26 Time: 19:51
Sample (adjusted): 1991 2023
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LREER(-1)	-0.814498	0.122390	-6.654920	0.0000
C	3.988925	0.612246	6.515237	0.0000
@TREND("1990")	-0.010301	0.002432	-4.235327	0.0002

Source: Prepared by the researchers using EViews 12 software

Table 5. ADF Test Results for Oil Prices

Null Hypothesis: LOIL has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.062949	0.5465
Test critical values:	1% level	-4.262735	
	5% level	-3.552973	
	10% level	-3.209642	

Null Hypothesis: D(LOIL) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.481345	0.0005
Test critical values:	1% level	-4.284580	
	5% level	-3.562882	
	10% level	-3.215267	

Null Hypothesis: LOIL has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.101142	0.7036
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

Null Hypothesis: D(LOIL) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.584588	0.0001
Test critical values:	1% level	-3.661661	
	5% level	-2.960411	
	10% level	-2.619160	

Null Hypothesis: LOIL has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.558106	0.8316
Test critical values:	1% level	-2.636901	
	5% level	-1.951332	
	10% level	-1.610747	

Null Hypothesis: D(LOIL) has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.437024	0.0000
Test critical values:	1% level	-2.641672	
	5% level	-1.952066	
	10% level	-1.610400	

Source: Prepared by the researchers using EViews 12 software

Table 4. ADF Test Results for Trade Openness

Null Hypothesis: LOPEN has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.728149	0.9618
Test critical values:	1% level	-4.284580	
	5% level	-3.562882	
	10% level	-3.215267	

Null Hypothesis: D(LOPEN) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.163097	0.0000
Test critical values:	1% level	-4.284580	
	5% level	-3.562882	
	10% level	-3.215267	

Null Hypothesis: LOPEN has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.133906	0.2339
Test critical values:	1% level	-3.711457	
	5% level	-2.981038	
	10% level	-2.629906	

Null Hypothesis: D(LOPEN) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.610740	0.0000
Test critical values:	1% level	-3.661661	
	5% level	-2.960411	
	10% level	-2.619160	

Null Hypothesis: LOPEN has a unit root
Exogenous: None
Lag Length: 5 (Automatic - based on SIC, maxlag=8)

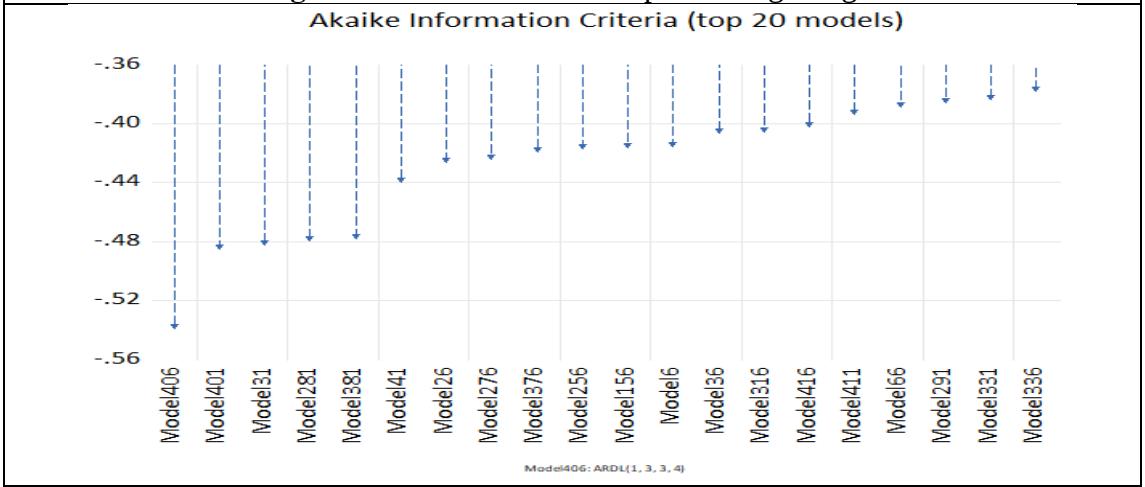
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.485238	0.4966
Test critical values:	1% level	-2.650145	
	5% level	-1.953381	
	10% level	-1.609798	

Null Hypothesis: D(LOPEN) has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.716590	0.0000
Test critical values:	1% level	-2.641672	
	5% level	-1.952066	
	10% level	-1.610400	

Source: Prepared by the researchers using EViews 12 software

Fig.3. Determination of the Optimal Lag Length



Source: Prepared by the researchers using EViews 12 software

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Table 1. Breusch–Godfrey LM Test for Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	2.885294	Prob. F(2,13)	0.0918
Obs*R-squared	9.222813	Prob. Chi-Square(2)	0.0099

Source: Prepared by the researchers using EViews 12 software

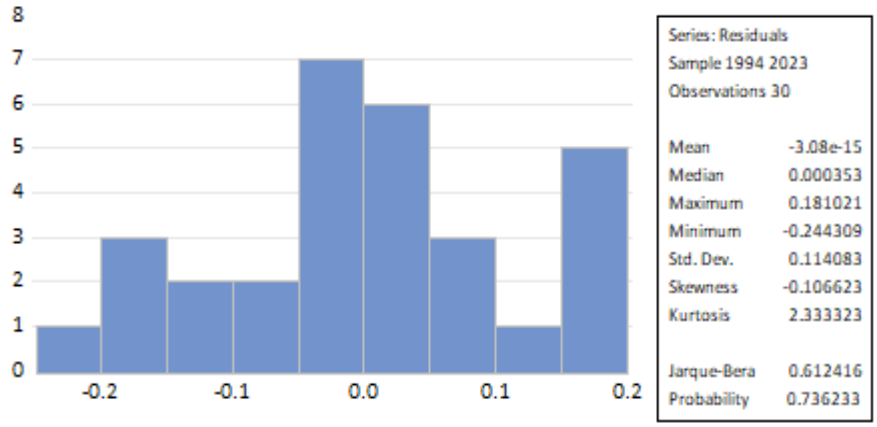
Table 1. ARCH Test for Heteroskedasticity

Heteroskedasticity Test: ARCH

F-statistic	1.607694	Prob. F(1,27)	0.2156
Obs*R-squared	1.629740	Prob. Chi-Square(1)	0.2017

Source: Prepared by the researchers using EViews 12 software

Fig.4. Residual Normality Test (Jarque–Bera)



Source: Prepared by the researchers using EViews 12 softwareV

Fig.5. Figure: CUSUM Test

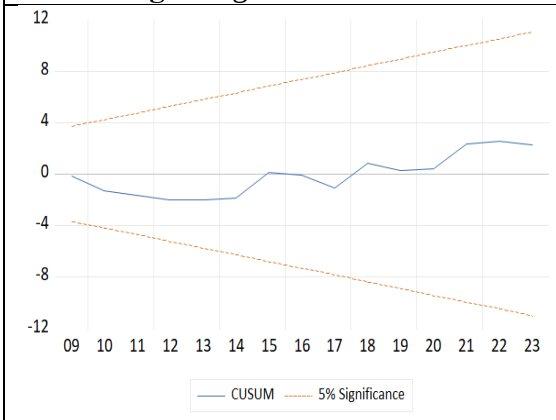
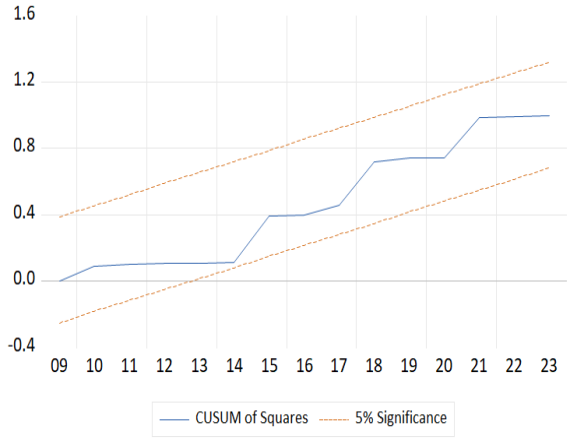


Fig.6. CUSUMSQ Test



Source: Prepared by the researchers using EViews 12 software