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The Dynamics of Foreign Exchange Reserves in Algeria and External Financial Stability: An Econometric Study Using the QARDL Model (1990-2024)

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Abstract:
This study aims to analyze the asymmetric dynamics of international foreign exchange reserves in Algeria over the period 1990–2024, focusing on their response to macroeconomic determinants (oil prices, money supply, trade openness, and real effective exchange rate) across varying economic states of crisis "scarcity" and boom "abundance". To overcome the methodological limitations of classical linear models that assume structural symmetry, this study employs the Quantile Autoregressive Distributed Lag (QARDL) methodology. The empirical results reveal the existence of a robust non-linear cointegrating relationship, indicating that economic behavior fundamentally diverges based on the magnitude of available financial buffers. Long-run estimates indicate a diminishing marginal utility of oil revenues during periods of abundance, counterbalanced by a multiplied and explosive impact of the money supply, reflecting the "rent monetization" syndrome. Furthermore, the findings demonstrate that trade openness exerts a more severe depleting pressure and faster impact during scarcity crises compared to boom periods. The study recommends decoupling monetary policy from oil rents, institutionalizing a counter-cyclical sovereign management to absorb shocks, and shifting towards dynamic exchange rate management to ensure external financial sustainability.

Keywords: *International Reserves; Oil Prices; QARDL Model; Structural Asymmetry; Monetary Policy; Algerian Economy.*

I. INTRODUCTION

International foreign exchange reserves represent the first strategic line of defense and the paramount financial buffer for developing and emerging countries confronting external shocks and global economic volatility. Amidst the intricacies of the international financial system and escalating trade exposure, reserve management is no longer merely an instrument to ensure exchange rate stability and import coverage. Rather, it has evolved into a sovereign indicator reflecting a nation's financial solvency and its capacity to absorb crises without compromising the trajectory of sustainable development. This dynamic assumes even greater complexity in rentier economies, where reserve levels are mechanically and directly tethered to the severe, day-to-day fluctuations of global energy markets.

The Algerian economy serves as an archetypal paradigm for examining this complex phenomenon. It is characterized by a dual structural dependency: a profound reliance on the hydrocarbon sector as the near-exclusive source of foreign currency, coupled with an external dependence to satisfy domestic demand through imports. Over the past three decades (1990–2024), Algeria has navigated paradoxical economic cycles, oscillating between suffocating financial crises that precipitated severe reserve depletion (periods of "scarcity") and exceptional oil booms that facilitated the accumulation of a massive, historic financial bulwark (periods of "abundance"). This profound volatility renders Algeria's external financial stability highly sensitive to monetary policies (money supply), trade policies (trade openness), and domestic currency valuation trajectories (real effective exchange rate).

The central problematic motivating this study lies in the methodological shortcomings of preceding empirical literature. The vast majority of studies examining the determinants of foreign reserves have relied heavily on linear econometric models that postulate "structural symmetry" and estimate the impact of variables based on the "conditional mean." This classical approach assumes that the response of reserves to a shock in oil prices or the money supply remains constant and uniform, regardless of whether the state is experiencing the peak of a financial boom or suffering from a severe depletion crisis. However, economic reality and policymaking dictate otherwise; economic policies and their subsequent impacts are inherently state-dependent, shifting radically according to the magnitude of available financial buffers at the precise moment a shock occurs.

To bridge this epistemological and methodological gap, this study aims to provide an advanced quantitative analysis of international reserve dynamics in Algeria across the entire conditional distribution of the data, effectively transcending the limitations of linear modeling. To achieve this, the study employs the Quantile Autoregressive Distributed Lag (QARDL) methodology developed by Cho et al. (2015). This pioneering approach enables the testing of whether the short- and long-run relationships between reserves and their macroeconomic determinants exhibit structural asymmetry across varying economic states (lower quantiles representing scarcity, and upper quantiles representing abundance).

This study derives its significance and scientific contribution from two primary trajectories. First, it provides robust, contemporary empirical evidence covering a transformative timeframe (1990–2024), thereby enriching the economic literature regarding reserve sustainability in oil-exporting nations. Second, the study's empirical outputs equip financial and monetary policymakers in Algeria with precise analytical tools. This facilitates the design of effective "counter-cyclical policies" and enhances the comprehension of the adverse effects of expansionary monetary policy (rent monetization) and trade openness dynamics. By contextualizing these macroeconomic determinants within the scarcity-abundance dichotomy, the study ultimately contributes to fortifying the long-term resilience of the national economy.

I. Theoretical Framework and Literature Review

1. Theoretical Foundations: Precautionary vs. Mercantilist Paradigms

The theoretical discourse surrounding the accumulation of foreign exchange reserves is predominantly anchored by two competing paradigms: the mercantilist and precautionary approaches. The mercantilist perspective postulates that reserves are systematically accumulated as a deliberate policy tool to maintain an undervalued, highly competitive exchange rate, thereby stimulating export-led economic growth (Karim et al., 2021). This approach has historically characterized several Asian emerging markets but falls short in explaining the behaviors of structurally distinct economies.

Conversely, the precautionary motive frames reserve accumulation as a vital macroeconomic self-insurance mechanism. From this viewpoint, reserves are deployed to defend against sudden stops in capital flows, speculative currency attacks, and severe external shocks (Đolić et al., 2024). For emerging economies heavily reliant on volatile primary commodities, such as Algeria, the precautionary motivation is unequivocally dominant. Given the structural vulnerabilities and extreme exposure to the boom-and-bust cycles of global energy markets, reserves act as the primary macroeconomic buffer. They safeguard the balance of payments, ensure sufficient liquidity to meet external obligations, and mitigate the structural inequalities inherent in the global financial system (Dinh et al., 2024; Yukhymenko & Skrypnyk, 2025; Ikoh et al., 2026). Furthermore, the theoretical literature emphasizes that the strategic diversification of these reserves—such as incorporating monetary gold alongside foreign currencies—is indispensable for preserving the efficacy of monetary policy transmission and ensuring long-term external financial resilience (Chuvakhina, 2023).

2. Macroeconomic Determinants of Reserves and External Stability

The trajectory of foreign exchange reserve accumulation is dictated by a complex nexus of macroeconomic fundamentals, external debt profiles, and the depth of domestic financial institutions. Empirical consensus robustly identifies the trade balance, inflation rates, and foreign direct investment (FDI) as the primary macro-drivers of reserve adequacy in developing nations (Islam et al., 2025). In resource-rich and developing regions, researchers have documented that inflation and relentless import demand exert profound, long-run draining pressures on reserve holdings, often overshadowing considerations of capital mobility (Sanusi et al., 2019; Arize & Malindretos, 2012).

Beyond standard macroeconomic variables, external stability is critically tethered to capital flow volatility and external debt burdens. While temporary periods of massive financial inflows—termed "capital flow bonanzas"—can artificially inflate reserve levels, they concurrently heighten a developing country's vulnerability to sudden capital flight, currency depreciation, and subsequent debt crises (Reinhart & Reinhart, 2009; Randi et al., 2023). Therefore, maintaining external stability requires highly synchronized monetary and exchange rate policies. Central banks are forced to navigate the policy trilemma, carefully calibrating exchange rate regimes to absorb external shocks without compromising domestic inflation targets or autonomous monetary policy (Fischer, 2001; Stepanenko et al., 2025; Lane et al., 2014; Taylor, 1995).

Moreover, the success of these stabilization mechanisms is heavily contingent upon institutional capacity. The developmental depth of domestic financial markets, along with strong institutional quality, acts as a transmission channel that mediates how effectively reserves can be deployed during economic distress (Claessens, 2006; Horen et al., 2012). Prudent reserve management must also be coupled with responsive fiscal policies and balance of payments forecasting to shield the economy from internal vulnerabilities and systemic global risks (Paslavska & Popovich, 2025; Storoshchuk et al., 2024; Hladynets & Kuzmenko, 2025).

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II. Empirical Evidence and the Research Gap:

Empirical investigations into the nexus of reserve dynamics and financial stability reveal substantial heterogeneity across global and regional contexts. Globally, studies utilizing advanced cointegration techniques have repeatedly validated the long-run equilibrium between reserve adequacy, exchange rate volatility, and overarching macroeconomic stability (Al-Malkawi et al., 2012; Devesh et al., 2023; Rasool et al., 2021). Robust multidimensional assessments, such as the Z-score for banking stability, highlight how exchange rate depreciations and foreign liabilities interact to influence national financial resilience (Dinh et al., 2024; Winpor & Hidayat, 2024). Complications like financial dollarization and varying levels of corporate governance further necessitate nuanced empirical modeling to accurately assess external stability (Yeyati, 2006; El-Chaarani et al., 2022).

Within the Middle East and North Africa (MENA) region, the literature underscores a unique set of challenges. High external resource dependence exacerbates systemic vulnerabilities, making proactive reserve management essential for buffering volatile capital flows, avoiding reliance on international financial assistance (e.g., IMF programs), and supporting regional economic integration (Bondarenko & Sannikov, 2025; Loiko & Golynskyi, 2025; Leblang, 1999; Fischer, 2001).

In the specific context of Algeria, existing empirical literature provides foundational insights but suffers from notable methodological constraints. For instance, Bourenane et al. (2022) utilized a standard ARDL model to successfully establish a positive long-run relationship between Algeria's foreign exchange reserves and FDI inflows over the 1990–2020 period. However, relying on conventional, symmetric econometric modeling (e.g., Pattak et al., 2023) is demonstrably insufficient for capturing the non-linear realities of a hydrocarbon-based economy. Oil price crashes and sudden windfalls do not generate symmetrical responses in Algerian reserve accumulation or trade openness.

A critical void remains in the literature regarding the asymmetric, quantile-dependent nature of macroeconomic shocks on Algeria’s external stability. Previous studies have largely neglected how the impacts of oil prices (OILP), broad money supply (M2), and trade openness (OPEN) fluctuate across varying states of reserve adequacy. This paper directly addresses this gap by employing the QARDL framework for the period 1990–2024, offering a pioneering analysis of how these macroeconomic determinants uniquely behave during periods of severe reserve depletion (crises/scarcity) versus periods of high accumulation (boom/abundance). By doing so, it provides actionable, state-dependent policy insights for navigating structural vulnerabilities in rentier economies.

III. Methods and Materials:

Building upon the theoretical framework and the analytical gaps identified in the literature review, this section transitions from theoretical abstraction to applied econometric modeling. This empirical analysis aims to quantitatively test the study's hypotheses by estimating the impact of oil price volatility and macroeconomic determinants on the dynamics of international foreign exchange reserves in Algeria—a fundamental pillar of external financial stability—over the period 1990–2024.

This study adopts a methodological philosophy that rejects classical linear assumptions. Such assumptions have proven fundamentally inadequate in capturing structural breaks and abrupt shifts in rentier economies highly vulnerable to external shocks, primarily because they predicate temporal homogeneity in economic behavior based on the conditional mean of the data. As a robust methodological alternative, this research employs the Quantile Autoregressive Distributed Lag (QARDL) framework developed by Cho et al. (2015) as an advanced

econometric tool. This model facilitates the capturing of asymmetric structural responses, which diverge substantially depending on the economy's position on the reserve adequacy curve—whether in states of "scarcity and crisis" at lower quantiles, equilibrium at the median, or "abundance and financial booms" at upper quantiles.

1. Identification and Description of Study Variables

The study relies on annual data covering the period 1990–2024. This strategic timeframe encompasses successive and contrasting oil price cycles (the crisis of the 1990s, the boom of the 2000s, and the 2014 shock and its aftermath), as well as structural transformations in Algeria's reserve management policy. The data were sourced from the International Monetary Fund (IMF) databases and the World Bank's World Development Indicators (WDI).

In strict adherence to the methodological rigor of the chosen model, all variables were retained in their original levels, percentages, and indices without any logarithmic transformation. This approach ensures a direct and economically sound interpretation of the results while preventing any distortion of the quantile distributions of the shocks.

Table 1: Definition, Notation, and Sources of the Study Variables

Variable	Notation	Unit of Measurement	Economic Description and Source
International Reserves	RRES	% of GDP	**Dependent Variable:** Total reserves minus gold. Reflects the economy's capacity to absorb external shocks and meet external financial obligations (Source: World Bank).
Oil Prices	OILP	US Dollars per Barrel ()	Average Brent crude price. Represents the benchmark for external shocks and Algeria's primary source of economic rent (Source: World Bank/IMF).
Real Effective Exchange Rate	REER	Index	Measures the economy's external competitiveness and the impact of currency fluctuations on the valuation of foreign assets and balance of payments flows (Source: IMF).
Trade Openness	OPEN	% of GDP	Sum of exports and imports as a share of GDP. Captures the degree of the Algerian economy's exposure to international trade (Source: World Bank).
Broad Money Supply	M2	% of GDP	Broad money. An indicator of economic liquidity, monetary expansion, and the extent of monetary policy intervention (Source: World Bank).

Source: Author's compilation.

2. Econometric Model Specification (QARDL)

To highlight the asymmetric dynamics of cointegration across varying levels of reserve accumulation, the QARDL model to be estimated is specified according to the following mathematical equation:

$$\Delta RRES_t = \alpha(\tau) + \rho(\tau)RRES_{t-1} + \sum_{k=1}^{4} \beta_k(\tau)X_{k,t-1} + \sum_{i=1}^{p-1} \phi_i(\tau)\Delta RRES_{t-i} + \sum_{k=1}^{4}\sum_{j=0}^{q-1} \gamma_{k,j}(\tau)\Delta X_{k,t-j} + \varepsilon_t(\tau)$$

- τ: Represents the quantile (segment) of the dependent variable's conditional distribution, where $\tau \in (0,1)$. Specifically, this study focuses on the quantiles $\tau = 0.25, 0.50, 0.75$ to represent the states of scarcity, equilibrium, and abundance, respectively.
- $RRES_t$: The dependent variable (International Reserves).
- $X_{k,t}$: The vector of independent macroeconomic variables comprising $(OILP, REER, OPEN, M2)$.
- $\alpha(\tau)$: The intercept (constant) term, which is allowed to vary across different quantiles.
- $\rho(\tau)$: The Error Correction Mechanism (ECM) parameter, which measures the speed of adjustment toward the long-run equilibrium at each quantile τ.
- $\beta_k(\tau)$: The long-run parameters, measuring the structural impact of macroeconomic variables on foreign reserves across different conditional distributions.
- $\phi_i(\tau)$ and $\gamma_{k,j}(\tau)$: The short-run parameters, capturing the "stickiness" of the response and the immediate dynamic transmission of oil price and macroeconomic policy shocks.
- $\varepsilon_t(\tau)$: The stochastic error term associated with quantile τ, reflecting unexplained shocks within the model.

IV. Results and discussion :

1. **Stationarity Tests and Time-Series Properties: The Quantile Unit Root (QADF) Methodology**

Prior to estimating the QARDL model parameters, standard econometric procedure necessitates an examination of the stochastic properties of the time series under investigation. To transcend the methodological limitations of classical unit root tests, which are strictly anchored to the "conditional mean," this study employs the Quantile Autoregressive Distributed Lag (QADF) test developed by Koenker and Xiao (2004). This test is distinguished by its capability to evaluate stationarity across the entire conditional distribution of the time series. However, in rentier economies subjected to successive structural shocks, time series may exhibit paradoxical behavior (e.g., demonstrating stationarity during periods of scarcity and non-stationarity during periods of abundance), thereby creating ambiguity regarding the variable's true order of integration.

To resolve this potential contradiction and decisively ascertain the degree of stationarity with rigorous mathematical precision, this study relies on "Global Test Statistics" as the definitive econometric benchmark. These statistics—specifically, the Kolmogorov-Smirnov-type statistic and the Cramér-von Mises-type statistic—measure the overall extent to which the

null hypothesis of a unit root is rejected across the entire distributional range, rather than relying solely on isolated, individual quantiles.

Table (2): Quantile Unit Root Test Results (Koenker & Xiao, 2004 QADF Test)

Variable	Integration Level	Lower Quantile τ=0.25 (Scarcity)	Median Quantile τ=0.50 (Equilibrium)	Upper Quantile τ=0.75 (Abundance)
RRES	Level	-2.3554 *	-1.3464	-0.1322
	1st Diff	-2.5649 **	-2.8300 **	-2.9924 **
REER	Level	-1.7556	-2.3760 *	-1.4444
	1st Diff	-3.2590 ***	-3.8284 ***	-2.7972 **
OPEN	Level	0.0506	-0.5966	-1.8037
	1st Diff	-4.9426 ***	-3.1382 ***	-3.7221 ***
M2	Level	0.1902	-1.1985	-0.7870
	1st Diff	-3.6189 ***	-4.9775 ***	-2.6530 **
OILP	Level	-1.5499	-0.4098	2.2405
	1st Diff	-2.8141**	-3.7752 ***	-3.2373 ***

Source: Prepared by the author based on STATA 17 software.

Note: (*), (**), and (***) denote the rejection of the null hypothesis (presence of a unit root) at the 10%, 5%, and 1% significance levels, respectively, by comparing the t_n *statistic against the critical values (CV).*

The results of the global tests at the series' levels reveal deeply entrenched unit roots across most macroeconomic time series. For instance, the global statistics for trade openness (OPEN) and money supply (M2) at their levels exhibited relatively low values for the Kolmogorov-Smirnov statistics, recording 1.8037 and 1.1985, respectively. These were corroborated by weak Cramér-von Mises values that did not exceed 0.9029 and 0.5230. Similarly, despite momentary fluctuations, oil prices (OILP) comprehensively failed to reject the unit root hypothesis at the level. This behavior confirms that shocks impacting these variables leave permanent effects (permanent shocks), preventing their automatic reversion to their means across various economic conditions.

Conversely, upon conducting the global tests on the first differences of the variables, radical and statistically compelling structural shifts emerge. The Kolmogorov-Smirnov statistic for oil prices (d.OILP) surged to 3.7752, while the Cramér-von Mises statistic doubled to record 7.1972, reflecting an unequivocal rejection of the unit root hypothesis across the entire data distribution. This decisive pattern extended even more forcefully to variables such as trade openness (d.OPEN) and money supply (d.M2), where the Kolmogorov-Smirnov statistics registered peak levels of 4.9426 and 4.9775, respectively, accompanied by exceptional Cramér-von Mises values (12.03 and 11.22). This conclusively establishes their stationarity. Regarding the dependent variable, the reserve ratio (d.RRES), the global statistics affirmed its full stationarity at the first difference, superseding the variance recorded at its levels.

Based on this analytical reading grounded in the comprehensive Koenker and Xiao global statistics, we conclude that there are no contradictions obstructing the econometric modeling. The integrated results confirm that all study variables are exclusively distributed between integration of order zero I(0) and integration of order one I(1) comprehensively across all

quantiles, with a categorical confirmation of the absence of any variable integrated of order two I(2). This rigorous conclusion perfectly satisfies the fundamental precondition for applying the QARDL bounds testing methodology.

2. **Cointegration and Structural Asymmetry Tests**

To validate the economic hypotheses concerning the asymmetric behavior of foreign reserves, the Quantile Autoregressive Distributed Lag (QARDL) model was estimated, and the stability of both long- and short-run parameters across the conditional quantiles was examined using Wald tests. The empirical results unequivocally reject classical linear assumptions, yielding statistically significant Wald statistics at the 1% level for both the long-run and short-run parameters. This decisive rejection confirms the presence of a non-linear cointegrating relationship, indicating that the macroeconomic impacts on reserves diverge substantially between states of "scarcity" $(\tau = 0.25)$ and "abundance" ($\tau = 0.75$).

Table (X): Results of Cointegration and Structural Asymmetry Tests for the QARDL Model

Test Type / Variable Evaluated	Wald Statistic	P-value	Conclusion / Economic Decision
Joint Cointegration Tests			
Stability of long-run parameters $W(\beta)$	399.92	0.000 ***	Null hypothesis rejected (non-linear cointegration exists)
Stability of short-run parameters $W(\gamma)$	2876.58	0.000 ***	Null hypothesis rejected (asymmetric dynamics exist)
Stability of the error correction parameter $W(\phi)$	69.79	0.000 ***	Null hypothesis rejected (variable speed of adjustment)

Source: Prepared by the author based on STATA 17 software.

*Note: (**) and (***) denote statistical significance at the 1% and 5% levels, respectively. "Null hypothesis rejected" refers to the rejection of parameter constancy, thereby validating the employment of the asymmetric model.**

Furthermore, the error correction parameters corroborate the existence of an effective equilibrating mechanism. Across all evaluated quantiles, the value of the parameter is negative and highly significant (p-value = 0.000), proving the inevitability of reversion to the long-run equilibrium. From an economic standpoint, it is notable that the "speed of adjustment" increases proportionally with the volume of reserves. The economy corrects its imbalances relatively sluggishly during periods of scarcity and crisis (at 28.5% annually), whereas the efficiency of this adjustment rises markedly during financial booms and periods of abundance (at 37.3% annually). This dynamic reflects the high resilience afforded by substantial fiscal buffers in absorbing macroeconomic shocks.

3. **Long-Run Dynamics**

The long-run outputs (β) reveal a profound structural divergence in the behavior of macroeconomic determinants contingent upon the economy's position within the quantitative distribution of reserves:

Table (...): Long-run Estimation Results

Test Type / Variable Evaluated	Wald Statistic	P-value	Conclusion / Economic Decision
Long-Run Asymmetry Tests (by Variable)			
Money Supply (M2)	94.78	0.000 ***	Asymmetric parameters (structural variation across quantiles)
Trade Openness (OPEN)	28.39	0.000 ***	Asymmetric parameters (structural variation across quantiles)
Real Effective Exchange Rate (REER)	8.21	0.016 **	Asymmetric parameters (structural variation across quantiles)
Oil Prices (OILP)	25.57	0.000 ***	Asymmetric parameters (structural variation across quantiles)

Source: Prepared by the author based on STATA 17 software.

- **Oil Price Shocks (OILP):**

Oil prices exert a positive and highly significant impact (p=0.000) across all quantiles. However, the magnitude of this effect follows a downward trajectory, reflecting a structural reality of the Algerian economy. During periods of "scarcity" (at the 0.25 quantile), the oil impact reaches its zenith $(\beta = 0.2814)$. This is explained by the fact that the marginal utility of oil revenues is maximized when reserves are depleted, as any increase in the price per barrel is immediately and acutely directed toward rebuilding reserves and securing essential imports. Conversely, this effect diminishes substantially during periods of "abundance" ($\beta = 0.1365$ at the 0.75 quantile). This decline is attributable to a "leakage effect," whereby authorities tend to channel oil windfalls during boom periods into expansionary public spending, infrastructure projects, or sovereign wealth funds, thereby reducing the sensitivity of direct reserve accumulation to price surges.

- **Money Supply (M2):**

The monetary variable exhibits a behavior entirely antithetical to that of oil. During periods of scarcity, the correlation between the money supply and reserves is weak ($\beta = 0.2543$). Yet, as the economy transitions to levels of "abundance" ($\tau = 0.75$), the impact erupts, manifesting a sharp multiplier effect $(\beta = 1.0499)$. This accurately mirrors the "rent monetization" mechanism tied to hydrocarbon revenues in Algeria. In times of abundance, the central bank intervenes by purchasing oil revenues from the national hydrocarbon company in exchange for injecting the equivalent in dinars (M2 expansion). This creates a robust, direct mechanical linkage between the money supply and elevated levels of foreign reserves.

- **Trade Openness (OPEN):**

Trade openness exerts the most severe pressure on foreign reserves, with average parameters exceeding (4.0). Notably, this impact peaks at the "scarcity" quantiles ($\beta = 4.3806$) and marginally decreases during "abundance" $(\beta = 3.8737)$. This scenario epitomizes the "structural rigidity" of Algerian imports (foodstuffs, pharmaceuticals, and capital equipment), which are largely indispensable. During financial crises, the magnitude of trade exposure becomes exceptionally burdensome and depletes reserves at an accelerated pace, often compelling policymakers to resort to administrative import restriction policies to stanch this hemorrhage.

- **Real Effective Exchange Rate (REER):**

The impact of the exchange rate assumes an approximately U-shaped curve. During scarcity, currency valuation contributes notably $(\beta = 0.1418)$ to preserving reserves as a shock-absorption and import-restriction mechanism. The variable completely loses its statistical significance at the conditional median (0.50 quantile), before rebounding to exert a stronger and more positive influence during periods of abundance $(\beta = 0.2189)$. This reflects the role of dinar valuation and its strategic management in maximizing the accounting value of external assets amidst abundant foreign exchange inflows.

4. **Short-Run Dynamics**

Table (...): Short-run Estimation Results

Variable / Indicator	**Lower Quantile τ=0.25 (Scarcity)**	**Median Quantile τ=0.50 (Equilibrium)**	**Upper Quantile τ=0.75 (Abundance)**
Short-Run Parameters γ (Short-Run)			
Oil Prices (OILP)	0.0804 ***	0.0639 ***	0.0510 ***
Money Supply (M2)	0.0726 ***	0.1666 ***	0.3924 ***
Trade Openness (OPEN)	1.2509 ***	1.3158 ***	1.4477 ***
Real Effective Exchange Rate (REER)	0.0405 ***	0.0190 ***	0.0818 ***
Error Correction Parameter (ρ)	**-0.2856 *****	**-0.3186 *****	**-0.3737 *****
Asymmetry Tests (Wald Tests)			
Long-Run $(W_{\{\beta\}})$	$\{c\}\{399.922\ (p-value\ =\ 0.000)***\}$		
Short-Run (W_{γ})	{c}{2876.578 (p-value = 0.000) ***}		

Source: Prepared by the author based on STATA 17 software.

The short-run parameters (γ) demonstrate that instantaneous (immediate) shocks transmit to foreign reserves through mechanisms distinct from those in the long run. Pairwise tests confirm the statistical significance of these structural differences (p=0.000).

The response of reserves to immediate oil shocks (OILP) is instantaneous and more pronounced during states of scarcity $(\gamma = 0.0804)$ compared to periods of abundance $(\gamma = 0.0510)$. Conversely, short-run shocks to the money supply (M2) emerge as the most rapid driver of reserves at higher quantiles $(\gamma = 0.3924)$. Regarding trade openness (OPEN), short-run shocks exert a stronger impact during periods of abundance $(\gamma = 1.4477)$ than during scarcity $(\gamma = 1.2509)$. Economically, this can be attributed to the "Wealth Effect." The sudden availability of substantial foreign liquidity triggers an immediate and voracious response

from economic agents to ramp up imports. This creates a swift shock to the balance of payments, reflecting the rapid outward leakage of foreign exchange as soon as it becomes available.

V. Conclusion:

This study aimed to decipher the complex dynamics of Algeria's international foreign exchange reserves—a fundamental pillar of external financial stability—over the period spanning from 1990 to 2024. Motivated by the methodological shortcomings of classical linear models in capturing the economic behavior of rentier states, this research adopted the Quantile Autoregressive Distributed Lag (QARDL) framework. This advanced methodology enabled the testing of the research hypotheses and the tracing of transmission channels for shocks to oil prices, monetary policy, trade openness, and currency valuation across heterogeneous economic states: periods of crisis and reserve depletion ("scarcity") versus periods of financial windfall ("abundance").

1. Main Empirical Findings

The econometric analysis provided conclusive evidence rejecting the hypothesis of "structural symmetry," confirming that macroeconomic determinants in Algeria exert non-linear effects that vary radically depending on the volume of accumulated reserves. The primary empirical findings are summarized as follows:

- **Diminishing Marginal Utility of Rent Revenues:** Despite the consistently positive impact of oil prices on reserves, the results demonstrated that this effect peaks during periods of "scarcity" $(\beta = 0.28)$ and declines sharply during "abundance" $(\beta = 0.13)$. This reflects a structural "leakage effect," where surplus oil revenues generated during economic booms are channeled into expansionary fiscal spending rather than the stringent precautionary accumulation that characterizes periods of crisis.
- **Rent Monetization Syndrome and Boom Cycles:** The study revealed a critical structural shift in the role of the money supply (M2). While its impact is marginal during periods of scarcity, it transforms into a highly influential driver during periods of abundance $(\beta = 1.04)$. This underscores the mechanical linkage between monetary policy and hydrocarbon revenues; the authorities' domestic monetization of foreign surpluses generates massive liquidity. This liquidity is mechanically tied to reserve accumulation, yet simultaneously engenders latent inflationary pressures.
- **Structural Rigidity of Trade Openness:** Trade openness (OPEN) constitutes the primary channel of depletion and pressure on reserves across all quantiles. However, its severity intensifies notably during crises and scarcity $(\beta = 4.38)$. This clearly translates the "structural import dependency" (for food, pharmaceuticals, and industrial goods), which is characterized by low price elasticity. Consequently, efforts to curb imports become sluggish and economically costly following collapses in oil prices.
- **Flexibility of Adjustment towards Equilibrium:** The error correction parameter (-0.318 at the median) confirmed the existence of a cointegration relationship. However, the speed of adjustment is faster and more efficient during times of abundance (37.3% annually) compared to periods of scarcity (28.5% annually). This proves that substantial fiscal buffers grant policymakers a broader and more flexible "time space" to absorb economic shocks.

2. Policy Implications

Predicated on the econometric outputs demonstrating that the behavior of the Algerian economy is "state-dependent," this study articulates a set of strategic recommendations directed at monetary and fiscal policymakers:

- **Decoupling Monetary Policy from Oil Rent:** The Bank of Algeria must abandon the passive liquidity management reliant on rent monetization. During periods of "abundance," it is recommended to implement more rigorous sterilization policies to mop up excess monetary liquidity (M2). Such measures would curb the "wealth effect" that precipitates an immediate explosion in imports, thereby mitigating the rapid leakage of reserves following positive oil price shocks.
- **Reforming the Structure of Trade Openness Beyond Administrative Solutions:** Given that trade openness constitutes a structural depletion shock (particularly during scarcity), exclusive reliance on quota systems or administrative import restrictions remains a temporary and unsustainable remedy. It is advised to reorient trade openness towards the importation of technology and intermediate inputs that support import substitution strategies and bolster non-hydrocarbon exports. This paradigm shift would transform openness from a "consumer" of hard currency into a "generator" of it.
- **Institutionalizing Counter-cyclical Management:** The study's findings indicate that the sensitivity of accumulation weakens during boom phases. To rectify this distortion, rigorous, legally binding fiscal rules must be activated to manage the Revenue Regulation Fund (FRR) or to establish a sovereign wealth fund. Under this framework, a predetermined fraction of oil surpluses must be sequestered during periods of abundance to shield it from political pressures for expansionary spending, functioning as a defensive buffer during periods of scarcity.
- **Dynamic Exchange Rate Policy:** Considering the significant role of the Real Effective Exchange Rate (REER) during both scarcity and abundance, adopting a "managed float" policy is highly recommended. The Bank of Algeria should utilize the exchange rate as a proactive, shock-absorbing instrument to shield the economy's competitiveness, rather than employing it merely as a strict accounting tool to manage budgetary deficits.

In conclusion, safeguarding Algeria's external financial stability must no longer remain hostage to the cyclical price fluctuations of global energy markets. This necessitates a paradigm shift from "reactive management" during crises of scarcity to "precautionary strategic management" during periods of abundance, underpinned by genuine economic diversification that eradicates the dominance of rent over macroeconomic dynamics.

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- **Appendices**

