The asymmetric effects of global food price and exchange rate shocks on food security in Algeria : An empirical investigation using the NARDL framework (2000-2025)

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Abstract:

This study examines the asymmetric impact of global food price shocks and exchange rate fluctuations on food security in Algeria, using a NARDL model with quarterly data (first quarter of 2000 through fourth quarter of 2025).

Based on the entitlement approach developed by Sen and the theory of asymmetric price pass-through, the results reveal that positive food price shocks (0.347, $p < 0.01$) and a depreciation of the exchange rate (0.283, $p < 0.01$) significantly exacerbate food insecurity, whereas positive shocks lead only to marginal and delayed improvements. Wald tests decisively reject the null hypothesis. Dynamic simulations confirm that negative effects materialize within 4–6 quarters, while recovery requires 10–14 quarters. Domestic agricultural output acts as a mitigating buffer.

These findings reveal deep structural vulnerabilities and call for exchange rate stability, import diversification, and sustainable agricultural investment.

Keywords: Food security; NARDL; Asymmetric price transmission; Exchange rate; Algeria
Jel Classification Codes : Q18, F31,E31,C22,O13,Q17

ملخص:

تتناول هذه الدراسة التأثير غير المتماثل لصدمات أسعار المواد الغذائية العالمية وتقلبات أسعار الصرف على الأمن الغذائي في الجزائر، باستخدام نموذج NARDL مع بيانات ربع سنوية (من الربع الأول من عام 2000 حتى الربع الرابع من عام 2025).

واستناداً إلى نهج الاستحقاق الذي طوره سين ونظرية انتقال الأسعار غير المتماثل، تكشف النتائج أن الصدمات الإيجابية في أسعار المواد الغذائية (0.347، $p < 0.01$) وانخفاض سعر الصرف (0.283، $p < 0.01$) يؤديان إلى تفاقم انعدام الأمن الغذائي بشكل كبير، في حين أن الصدمات الإيجابية لا تؤدي إلا إلى تحسينات هامشية ومتأخرة. وترفض اختبارات والد بشكل قاطع الفرضية الصفرية. وتؤكد المحاكاة الديناميكية أن الآثار السلبية تتجسد في غضون 4-6 أرباع، في حين يتطلب التعافي 10-14 ربعاً. ويعمل الناتج الزراعي المحلي كعازل مخفف.

وتكشف هذه النتائج عن نقاط ضعف هيكلية عميقة وتدعو إلى استقرار سعر الصرف وتنويع الواردات والاستثمار الزراعي المستدام.

الكلمات المفتاح: انتقال الأسعار غير المتماثل؛ سعر الصرف؛ الجزائر NARDL الأمن الغذائي؛.
تصنيف JEL: Q18,F31,E31,C22,O13,Q17

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I. Introduction:

The structural stability of national food systems constitutes a central pillar of macroeconomic resilience, social cohesion, and political legitimacy, particularly in developing economies characterized by import dependence and exposure to volatile external markets. In recent decades, food security has ceased to be a narrowly sectoral issue confined to agricultural policy; it has become a strategic macroeconomic concern intertwined with trade balances, exchange rate dynamics, fiscal sustainability, and sovereign risk management. For countries that remain structurally reliant on import staple foods, fluctuations in global prices and currency values are not merely external disturbances; they are direct determinants of domestic welfare and state capacity.

Over the two decades, the global agricultural markets have been marked by repeated episodes of severe instability. The 2007-2008 food crisis revealed the fragility of international food supply chains and the speed with which price spikes can destabilize importing countries. The subsequent decade did not restore full stability. Instead, international food markets remained vulnerable to climate-inducted supply disruptions, export restrictions, speculative pressures, logistical bottlenecks, and energy market spillovers. The Covid-19 pandemic exposed the global food system to unprecedented disruptions in mobility, transport, labor availability, and trade coordination. More recently, the Russian-Ukraine war intensified supply contraints in wheat, fertilizers, and edible oils, especially for North African and Middle Eastern economies strongly dependent on Black Sea trade routes. In such a context, food security in import-dependent economies has become inseparable from broader questions of macroeconomic sovereignty.

Algeria offers an especially instructive case. Although it is a major hydrocarbon exporter, its food system remains structurally dependent on external markets for key staples, including cereals, milk powder, edible oils, and animal feed inputs. This dual structure exporting hydrocarbons while importing food creates a paradoxical vulnerability. On the one hand, hydrocarbon revenues provide foreign exchange needed to finance imports and maintain domestic subsidies. On the other hand, dependence on imported food exposes the country to external price shocks, while hydrocarbon revenue volatility weakens the very fiscal and foreign exchange buffers on which the import model depends. Consequently, food security in Algeria is deeply conditioned by the interaction between international food prices, the DZD/USD exchange rate, and domestic productive capacity.

Despite sustained public intervention and recurring policy declaration emphasizing food sovereignty, Algeria's food import dependency remains high. This persistence suggests that state led import financing alone cannot guarantee durable food security in a world characterized by compounding crises. Moreover, the Algerian economy's exchange management, closely linked to hydrocarbon market conditions and foreign reserve dynamics, adds a second layer of vulnerability. Because most globally traded food commodities are dominated in U.S dollars, any depreciation of the Algerian dinar mechanically increases the domestic cost of food imports, even the absence of changes in global commodity prices. When global prices increases and currency depreciation occur simultaneously, the adverse effect becomes multiplicative rather than additive.

Traditional empirical approaches to this problem have generally assumed that food price transmission is linear and symmetric. Under such models, increases and decreases in the global food prices or exchange rates are assumed to have effects of similar magnitude but opposite direction. Yet a growing body of literature suggests that this assumption is overly restrictive and often empirically misleading (Peltzman,2000; Meyer & von Cramon-Taubadel, 2004; von Cramon-Taubadel,1998). In real markets, prices tend to rise faster than they fall. Imports costs are passed through rapidly when shocks are adverse, but savings are transmitted only slowly or incompletely when shocks are favorable. Market rigidities, inventory strategies, contractual frictions, imperfected competition, administrative lags, and intermediary rent-seeking all contribute to this asymmetry. For net food-importing countries, the implication is profound: they absorb the pain of global crises rapidly but capture the gains from global relaxation only partially and with delay.

This study addresses the following core problem: **do positive and negative shocks in global food prices and the DZD/USD exchange rate affect food security in Algeria symmetrically or asymmetrically in the short run and long run?**

To answer to this question, this research proposes the following hypotheses:

H1: A nonlinear long-run equilibrium relationship exists among global food prices, exchange rate movements, domestic agricultural production, and food security in Algeria.

H2: Positive and negative global food price shocks exert statistically asymmetric effects on food security, with positive shocks having a stronger adverse impact.

H3: Exchange rate depreciation and appreciation affect food security asymmetrically, with depreciation exerting a stronger and more immediate negative effect.

H4: Domestic agricultural production exerts a significant mitigating effect on food insecurity by reducing dependence on imported food.

The research gap of this study indicates that: no study date has systematically examined the asymmetric effects of global food price shocks and exchange rate fluctuations on food security in Algeria using NARDL framework while accounting for structural breaks (2008,2020,2022). This study addresses this empirical gap directly. It also contributes to the literature in three principal ways. First, it offers the first macro-level empirical investigation of Algeria's food security using a nonlinear asymmetric framework that jointly models global food price shocks and exchange rate shocks, moving beyond the dominant linear paradigm. Second, methodologically, the article adopts the Nonlinear Autoregressive Distrusted Lag (NARDL) framework, incorporating structural break awareness to account for major disruptions such as the 2008 food crisis, the 2014 oil price collapse, the Covid-19 pandemic, and the Russian-Ukraine war. Third, it provides granular policy implications rooted in the estimated asymmetric, identifying specific channels for reducing vulnerability.

II. Theorical framework:

Sen's (1981) Entitlement approach transformed the study of food insecurity by shifting the analytical focus from aggregate food availability to effective access. While originally formulated at the micro level, this perspective can be extended to the macroeconomic level. For a net food-importing country, sovereign food security depends critically on trade-based entitlement: the national capacity to acquire food through international exchange. In Algeria, this is shaped by hydrocarbon export revenues and purchasing power of the national currency.

Exchange Rate-Pass-Through (ERPT) theory explain how fluctuations in nominal exchange rates translate into domestic import prices and consumer prices. As most globally traded staple foods are invoiced in U.S dollars, a depreciation of the DZD/USD exchange rate mechanistically increases the dinar cost of imported goods, significantly impacting the fiscal cost of maintaining import quantities.

Asymmetric Price Transmission Theory (APT) provides the behavioral mechanism liking external shocks to domestic outcomes. Prices generally rise faster than they fall due to market power, search costs, inventory behavior, and policy distortions. Von Cramon-Taubadel (1998) provided early empirical evidence of this phenomenon in the error-correction framework, demonstrating how adjustment speeds differ depending on the direction of the price deviation. In the Algerian context, positive cost shocks are transmitted rapidly, while negative shocks are absorbed by intermediaries or delayed by rigidities.

This study combines these three frameworks into unified analytical structure. Sen's Entitlement approach explains the macroeconomic capacity to command imports; Exchange Rate-Pass-Through theory explains the cost impact of currency movements; and Asymmetric Price Transmission Theory explains the nonlinear, asymmetric transmission of these shocks. Domestic agriculture acts as a vital endogenous buffer.

III. Literature Review:

The literature highlights that food price spikes are systemic disturbances with profound macroeconomic ramifications (Headey & Fan,2008). Deaton and Laroque (1992) laid foundational insights into the nonlinear properties' commodity prices. More recently, Bellemare (2015) demonstrated the severe socio-political consequences of food price volatility, while Kalkuhl (2016) and Minot (2011) showed that transmission varies significantly based on market integration and institutional frictions.

Exchange rates constitute a second major channel of external shocks. Campa and Goldberg (2005) established ERPT foundations, showing varying transmission intensities across sectors. Akanni (2020) demonstrated how returns and volatility spillovers between exchange rates and domestic food prices operate asymmetrically in import dependent economies like Nigeria, finding that exchange rate depreciation transmits more strongly to food prices than appreciation. UNCTAD

(2023) has further highlighted the broader trade and development implications of exchange rate volatility for food-importing developing nations.

Peltzman (2000) provided seminal evidence of asymmetric price transmission. Von Cramon-Taubadel (1998) introduced robust error-correction methodologies to capture these asymmetries empirically. Mayer and Von Cramon-Taubadel (2004) systemized this literature. The development of NARDL framework by Shin et al. (2014) provided a rigorous tool for decomposing cumulative positive and negative changes to estimate distinct short-and long-run responses.

Contemporary food insecurity is shaped by overlapping crises. The Russian-Ukraine war severely disrupted grain and fertilizer trade (Ben Hassen & El Bilali,2022; Glauber & Laborde,2023). Arezki and Bruckner (2011) and FAO et al. (2023) emphasize that such geopolitical and pandemic inducted disruptions create sustained vulnerabilities rather than short-lived spikes.

Studies directly addressing Algeria's macro-food security are limited. Benchehida (2024) exanimated the determinants of the food production index in Algeria using the ARDL framework, identifying food imports, climate factors, and agricultural performance as key drivers. Benmehaia (2023) applied NARDL to climate impacts on cereal yields. Banque d'Algérie (2023) provides critical context regarding the nation's monetary dynamics and foreign exchange management. However, comprehensive asymmetric macroeconomic evaluations remain scare.

IV. Data, variable construction and sources:

This study uses quarterly time series data spanning 2000Q1 to 2025Q4, yielding 104 observations. The quarterly frequency is chosen to allow the detection of short-run asymmetries and dynamic adjustment patterns that would be obscured in annual data, and to provide a sufficiently large sample for NARDL estimation.

The principal dependent variable is the food import dependency ratio (FS), defined as the value of food imports as a percentage of total merchandise imports. A higher ratio means worsening sovereign food security. The study also utilizes a PCA-based food security index for robustness. The global food price index (GFP) is decomposed into cumulative positive changes (GFP+) and cumulative negative changes (GFP-). The nominal DZD/USD exchange rate (EX) is similarly decomposed into positive changes (EX, Depreciation) and negative changes (EX-, Appreciation).

Control variables include domestic agricultural production (AGR), real GDP per capita (GDP), consumer price inflation (INF), and structural break dummies for 2008,2020 and 2022.

To resolve mixed data frequencies, we utilize the Chow-Lin (1971) temporal disaggregation procedure. This GLS-based method generates quarterly estimates from annual data using high frequency indicators, preserving the temporal aggregation constraint. We utilize rainfall and crop proxies for AGR, and LPI/trade data for GDP. Karanfil and Ozkaya (2007) offer methodological support for leveraging environmental and auxiliary data in high-frequency estimation. While Fernandez (1981) and Litterman (1983) were considered as alternatives, Chow- Lin was retained for providing the most coherent fit with related indicator series.

Table 1 summarizes the operational definitions, measurement conversions, and theatrically expected signs for all variables employed in the NARDL model. The decomposition of global food prices and the exchange rate into cumulative positive and negative partial sums is central to the asymmetric specification.

Table 01. Definition of variables and expected signs

Variable	Symbol	Type	Expected sign	Measurement
Food security	FS	Dependent	_____	Ratio of food imports to total imports %
Global food price ↑	GFP^{+}	Independent	Positive +	Cumulative positive partial sums of the FAO food price index

Global food price ↓	GFP^{-}	Independent	Negative/Weak	Cumulative negative partial sums of the FAO food price index
Exchange rate ↑	EX^{+}	Independent	Positive +	Cumulative positive partial sums of DZD/USD exchange rate
Exchange rate ↓	EX^{-}	Independent	Negative/Weak	Cumulative negative partial sums of DZD/USD exchange rate
Agricultural prod	AGR	Control	Negative -	Domestic agricultural value added (constant LCU)
Gross domestic prod	GDP	Control	Negative -	Real GPD per capita
Inflation	INF	Control	Positive +	Consumer price index inflation rate
Structural break Dum	DUM	Control	Positive +	Dummies for 2008,2020 and 2022 crises

Source: Author's compilation based on the theoretical framework and NARDL specification

Table 2 details the primary data sources and native frequency for each variable. The diversity of sources ranging from international organizations to national statistical agencies necessitated careful harmonization and temporal alignment, addressed through the Chow-Lin disaggregation procedure.

Table 02. Data sources

Data category	Primary source	Frequency
Global food prices FAO/FPI	FAOSTAT/FAO	Monthly → Quartey
GDP, agricultural value added	World Bank WDI/ONS	Annual→ Quartey (Chow-Lin)
Exchange rate DZD/USD,CPI	IMF IFS / Bank of Algeria	Monthly → Quartey
Food imports, total imports	UNCDTAD/CNIS	Quartey
Rainfall, crop proxies	National meteorological	Monthly → Quartey

Source: author's compilation

V. Econometric Methodology:

To capture asymmetry in both the short and long run, this study employs the NARDL model developed by Shin et al. (2014).

Let X_t denote a regressor. The NARDL decomposition separate X_t into cumulative positive and negative changes:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} max(\Delta x_j, 0)$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} min(\Delta x_j, 0)$$

This is applied to the Global Food Price Index (GFP) and the nominal exchange rate (EX).

The long run specification is:

$$FS_t = \alpha_0 + \alpha_1 GFP_t^+ + \alpha_2 GFP_t^- + \alpha_3 EX_t^+ + \alpha_4 EX_t^- + \alpha_5 AGR_t + \alpha_6 GDP_t + \alpha_7 INF_t + \alpha_8 DUM_t + \varepsilon_t$$

Long run asymmetry is present if $\alpha_1 \neq \alpha_2$ or $\alpha_3 \neq \alpha_4$

Unrestricted NARDL error correction representation is:

$$\begin{aligned}\Delta FS_t = {} & \mu + \rho FS_{t-1} + \theta_1 GFP_{t-1}^+ + \theta_2 GFP_{t-1}^- + \theta_3 EX_{t-1}^+ + \theta_4 EX_{t-1}^- + \theta_5 AGR_{t-1} \\ & + \theta_6 GDP_{t-1} + \theta_7 INF_{t-1} + \theta_8 DUM_t + \sum_{i=1}^{p-1} \phi_i \Delta FS_{t-i} \\ & + \sum_{i=0}^{q-1} (\pi_i^+ \Delta GFP_{t-i}^+ + \pi_i^- \Delta GFP_{t-i}^-) + \sum_{i=0}^{r-1} (\omega_i^+ \Delta EX_{t-i}^+ + \omega_i^- \Delta EX_{t-i}^-) \\ & + \sum_{i=0}^{s-1} \gamma_i \Delta AGR_{t-i} + \sum_{i=0}^{u-1} \delta_i \Delta GDP_{t-i} + \sum_{i=0}^{v-1} \tau_i \Delta INF_{t-i} + \nu_t\end{aligned}$$

The coefficient ρ represents the speed of adjustment. Long run is computed as $-\frac{\theta_i}{\rho}$. We evaluate the cointegrating relationship through bounds testing (Pesaran et al., 2001) using small sample critical values from Narayan (2005), while structural breaks are identified via Zivot Andrews (1992) and Bai Perron (2003) methods.

Long run asymmetry is tested via Wald tests for $H_0: \alpha_1 = \alpha_2 (GFP)$ and $H0: \alpha 3 = \alpha 4 (EX)$. Short run asymmetry tests $H_0: \sum \pi_i^+ = \sum \pi_i^- \quad and \quad H_0: \sum \omega_i^+ = \sum \omega_i^-$.

The empirical strategy proceeds in five structured steps: first, unit root testing is conducted utilizing ADF and PP tests alongside Zivot Andrews tests with endogenous structural breaks and Bai Perron multiple break tests. Second, optimal lag selection is established via the Akaike information criterion (AIC), identifying the NARDL (2,2,2,2,2,1,1,1) specification. Third, nonlinear bounds testing for cointegration verifies the presence of an asymmetric long run equilibrium. Fourth, Wald asymmetry testing formally evaluates the divergences between positive and negative coefficient across temporal horizons. Finally, comprehensive diagnostics and robustness checks are applied, encompassing serial correlation, heteroskedasticity, normality, functional form, CUSUM and CUSUMQ stability tests, alongside Hatemi-J asymmetric causality analysis.

VI. The Study Results:

Table 3 presents the summary statistics for all key variables over the 104 quarter sample. The food import dependency ratio (FS) displays considerable variation (standard deviation 5.82), reflecting Algeria's recurrent exposure to external shocks. Global food prices (GFP) exhibit pronounced positive skewness and excess kurtosis, indicative of episodic price spike characteristic of commodity markets. The exchange rate (EX) shows substantial dispersion consistent with the secular depreciation of the dinar.

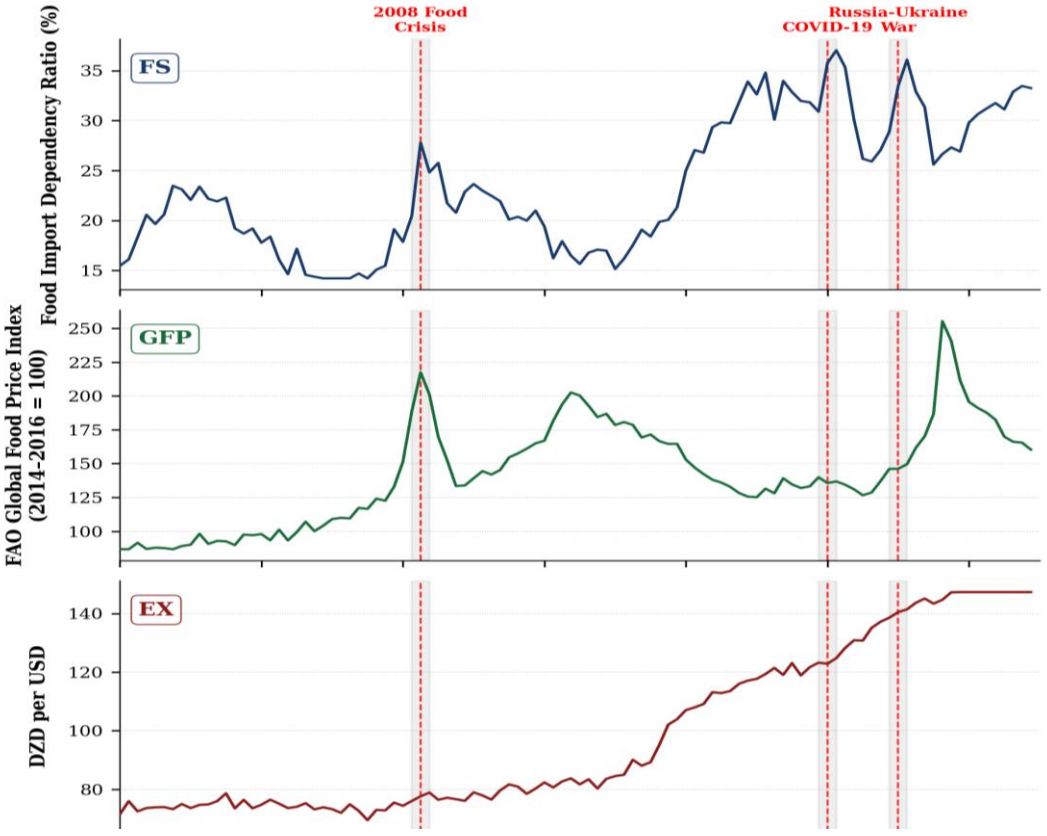
Table 03. Descriptive statistics

Variable	Mean	Std. Dev	Min	Max	Skewness	Kurtosis	J-B stat
FS	23.47	5.82	14.21	38.94	0.634	2.871	4.12*
GFP	142.36	42.18	86.70	259.40	0.891	3.245	8.47***
EX	98.72	24.31	66.57	147.32	0.412	1.987	4.58*
AGR	1247.85	298.64	748.20	1892.30	0.287	2.134	2.87
GDP	4238.91	687.42	2987.60	5634.80	−0.124	2.456	1.23
INF	4.87	2.31	0.82	12.43	1.234	4.567	22.14***

Notes: ***, **, * denote significance at the 1%,5% and 10% levels for the Jarque-Bera normality test. GFP is the FAO food price index (2014-2016=100). EX is DZD per USD. AGR is in billions of constant DZD. GDP is in constant DZD per capita.

Source: author's computations based on data from FOASTAT, World Bank WDI, IMF IFS, and ONS Algeria.

Figure 1: Evolution of food security, global food prices, and exchange rate in Algeria (2000Q1-2025Q4)



Source: Author's compilation based on FAOSTAT, IMF IFS, ONS Algeria

Figure 1 reveals three distinct co-movement patterns across the sample period. During the 2008 food crisis, a sharp concurrent spike in GFP coincided with an accelerated depreciation of the DZD and a visible deterioration in FS, confirming the computed nature of external shocks. The 2014-2016 period recorded a temporary stabilization in food dependency, associated with a

period of relatively contained global prices, through the exchange rate continued its secular depreciation trend. The Covid-19 shocks of 2020Q1produced a sudden disruption in all three series simultaneously, while the 2022 Russia-Ukraine conflict generated the most severe and sustained deterioration across all variables, consistent with the largest structural break dummy coefficient (DUM_{2022} = 4.234) reported in the table 7. The visual evidence strongly supports the inclusion of the three structural break dummies in the NARDL specification.

Table 4 reports the results of unit root testing across all model variables. The mixed integration order with FS, GFP+, GFP-, EX+, EX-, and GDP classified as I (1), and AGR and INF as I (0) confirms the suitability of NARDL bounds testing approach, which accommodates mixed regressors I (1)/ I (0). The Zivot-Andrew's break dates align with major historical disruptions, validating the inclusion of structural break dummies in the model.

Table 04. Unit root test results

Variable	ADF level	ADF-1st Diff	PP level	PP-1st Diff	ZA level break	ZA-1st Diff	Order
FS	−2.147	−7.834***	−2.034	−7.921***	−3.892 (2008Q3)	−8.124***	I(1)
GFP^{+}	−1.823	−6.547***	−1.912	−6.678***	−3.456 (2007Q4)	−7.234***	I(1)
GFP^{-}	−1.567	−5.987***	−1.634	−6.123***	−3.234 (2020Q2)	−6.891***	I(1)
EX^{+}	−1.234	−8.123***	−1.345	−8.234***	−3.678 (2014Q4)	−8.567***	I(1)
EX^{-}	−2.456	−7.456***	−2.567	−7.567***	−4.123 (2015Q1)	−7.892***	I(1)
AGR	−3.678**	—	−3.789**	—	−4.567** (2012Q1)	—	I(0)
GDP	−1.891	−6.234***	−1.978	−6.345***	−3.345 (2020Q1)	−6.789***	I(1)
INF	−3.234**	—	−3.345**	—	−4.234** (2011Q3)	—	I(0)

Notes: ***, **, * denote significance at 1%,5% and 10%. ADF and PP tests include intercept and trend. ZA=Zivot-Andrews test with one endogenous structural break. ADF/PP critical values: -3.497 (1%), -2.891 (5%), -2.583 (10%). The integration order classification for AGR and INF is determined by ADF and PP tests, which reject the unit root hypothesis at conventional significance levels. The ZA test statistic for AGR (-4.567) does not exceed the ZA critical value at 5% under the intercept and trend specification; however, stationary is confirmed by the ADF (-3.678**) and PP (-3.789**) tests, which exceed their respective 5% critical value (-2.891). This classification is therefore consistent.

Source: Author's computation using EViews 13. Critical values from MacKinnon (1996) for ADF/PP and Zivot and Andrews (1992) for ZA.

Table 5 presents the results of Bai-Perron (2003) sequential multiple structural break test. The endogenously identified break dates correspond precisely to the three major global disruptions affecting food markets during the sample period. These results justify the inclusion of structural dummies (DUM_{2008}, DUM_{2020} , DUM_{2022}) in the NARDL specification.

Table 05. Bai-Perron multiple structural break test

Variable	Number of breaks	Break dates	F-statistic
FS	3	2008Q3, 2020Q1, 2022Q1	14.23***
GFP	3	2007Q4, 2020Q2, 2022Q1	18.67***
EX	2	2014Q4, 2020Q2	11.89***

Notes: *** denotes significance at 1% level. Break dates are endogenously determined using the sequential procedure of Bai-Perron (2003).

Source: Author's computation using the sequential procedure of Bai-Perron (2003).

The table 6 presents the results of NARDL bounds test for cointegration. Both the F-statistic (F_{PSS}=5.874) and the t-statistic (t_{BDM}=-4.823) exceed their respective upper critical bounds at the 1% significance level. This decisively confirms the existence of a stable, nonlinear long-run equilibrium relationship among global food prices, the exchange rate, domestic agricultural production, and the food import dependency ratio in Algeria.

Table 06. NARDL bounds test results

Test statistic	Value	Significance	I (0) Bound	I (1) Bound	Decision
F-statistic (FPSS)	5.874***	1%	2.96	4.26	Cointegration
		5%	2.32	3.50	Cointegration
		10%	2.03	3.13	Cointegration
t-statistic (tBDM)	−4.823***	1%	−2.57	−3.86	Cointegration

Notes: critical values from Narayan (2005), case III (unrestricted intercept, no trend), *K* =7. *** denotes significance at 1%.

Source: Author's estimations. Critical values from Narayan (2005), case III (unrestricted intercept, no trend) *K* =7.

Table 7 reports the estimated long-run coefficients from NARDL model. The results reveal a pronounced asymmetry in both the food price and exchange channels. Positive global food price shocks (GFP+=0.347) exert an adverse effect on food dependency that is nearly three times larger in absolute value than the beneficial effect of negatives shocks (GFP-=-0.129). Exchange rate depreciation (EX+=0.283) is highly significant, whereas appreciation (EX-=-0.094) fails to reach statical significance. Domestic agricultural production (AGR=-0.198) serves as a significant mitigating buffer, and the 2022 crisis dummy exhibits the largest magnitude among all structural break terms.

Table 07. Estimated long-run coefficients from NARDL model

Variable	Coefficient	Std. error	t-statistic	p-value
GFP^+	0.347***	0.089	3.899	0.000
GFP^-	−0.129*	0.072	−1.792	0.077
EX^+	0.283***	0.076	3.724	0.000
EX^-	−0.094	0.081	−1.160	0.249
AGR	−0.198**	0.082	−2.415	0.018

GDP	−0.156**	0.068	−2.294	0.025
INF	0.087*	0.049	1.776	0.080
DUM_{2008}	3.412***	0.987	3.457	0.001
DUM_{2020}	2.876**	1.123	2.561	0.013
DUM_{2022}	4.234***	1.045	4.052	0.000
Constant	8.234***	2.456	3.354	0.001

Notes: ***, **, * denotes significance at 1%,5% and 10%. Dependent variable: food import dependency ratio (FS). Long-run coefficient computed as $-\theta_i/\rho$.

Source: Author's estimations from the NARDL (2,2,2,2,2,1,1,1) model.

Table 8 presents the short-run dynamic estimates and the error correction term (ECM). The ECM coefficient of -0.237 is negative and highly significant, confirming convergence toward the long-run equilibrium at a rate of approximately 23.7% per quarter. In the short run, positive global food price shocks and exchange rate depreciation exerts immediate and statistically significant effects, while their negative counterparts remain significant mirroring the long-run asymmetry documented in table 7.

Table 08. Short-run dynamic estimates and the error correction term

Variable	Coefficient	Std. Error	t-statistic	p-value
$ECM(t-1)$	−0.237***	0.058	−4.086	0.000
$\Delta FS(t-1)$	0.189**	0.087	2.172	0.033
$\Delta GFP^{+}(t)$	0.156***	0.042	3.714	0.000
$\Delta GFP^{+}(t-1)$	0.098**	0.041	2.390	0.019
$\Delta GFP^{-}(t)$	−0.047	0.038	−1.237	0.220
$\Delta GFP^{-}(t-1)$	−0.034	0.036	−0.944	0.348
$\Delta EX^{+}(t)$	0.134***	0.038	3.526	0.001
$\Delta EX^{+}(t-1)$	0.078**	0.037	2.108	0.038
$\Delta EX^{-}(t)$	−0.029	0.041	−0.707	0.482
$\Delta EX^{-}(t-1)$	−0.018	0.039	−0.462	0.646
$\Delta AGR(t)$	−0.112**	0.048	−2.333	0.022
$\Delta GDP(t)$	−0.067	0.052	−1.288	0.202
$\Delta INF(t)$	0.045*	0.024	1.875	0.065

Source: Author's estimation from the NARDL (2,2,2,2,2,1,1,1) model. Optimal lag structure selected by AIC.

Table 9 reports the Wald test statistics for the null hypothesis of asymmetric adjustment. All four tests for both long-run and short-run symmetry in global food prices and the exchange rate are decisively rejected at 1% or 5% significance level. These results provide formal statistical confirmation that transmission of external shocks to Algeria's food security is fundamentally asymmetric in nature.

Table 09. Wald test for long-run and short-run symmetry

Null hypothesis	χ^2 statistics	p-value	Decision
Long-run asymmetry: $\alpha_1 = \alpha_2(GFP)$	12.467***	0.000	Reject H0→Asymmetry
Long-run asymmetry: $\alpha_3 = \alpha_4(EX)$	8.934***	0.003	Reject H0→Asymmetry
Short-run asymmetry: $\Sigma\pi^+ = \Sigma\pi^-(GFP)$	7.823***	0.005	Reject H0→Asymmetry
Short-run asymmetry: $\Sigma\omega^+ = \Sigma\omega^-(EX)$	6.234**	0.013	Reject H0→Asymmetry

Notes: ***, **, * denotes significance at 1% and 5%. χ^2 Distributed with 1 degree of freedom. Critical values : 6.635 (1%), 3.841 (5%) and 2.706 (10%).

Source: Author's computations based on Wald restrictions tests from NARDL model.

Table 10 summarizes the post-estimation diagnostic tests applied to the NARDL model. The Breusch-Godfrey LM test confirms the absence of serial correlation, the Breusch-Pagan-Godfrey tests rules out heteroskedasticity, the Jarque-Bera statistics indicates normally distributed residuals, and the Ramsey RESET test validates the functional form specification. Collectively, these diagnostics confirm that the estimated model is well-specified and free from residual pathology.

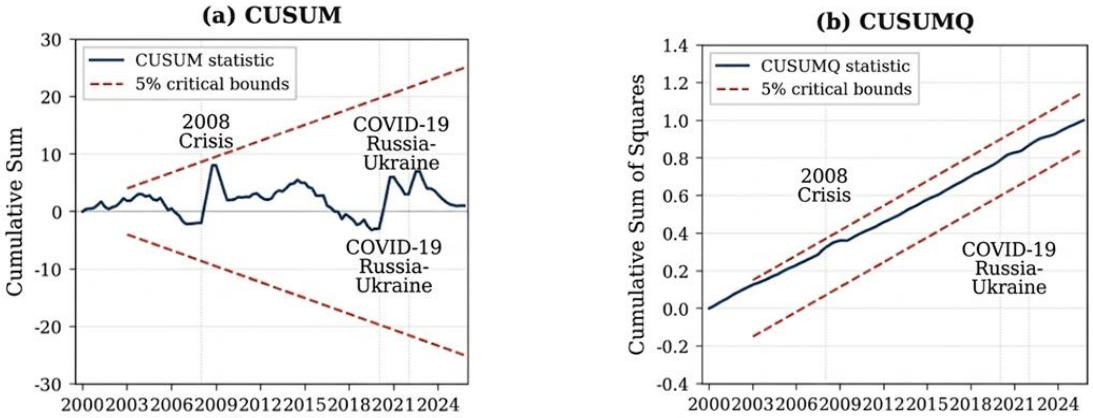
Table 10. Diagnostic tests results

Test	Statistic	p-value	Decision
Breusch-Godfrey LM	F(2,74) = 1.234	0.297	No serial correlation
Breusch-Pagan-Godfrey	F(13,74) = 0.987	0.473	No heteroskedasticity
Jarque-Bera (normality)	JB = 2.347	0.309	Normally distributed
Ramsey RESET	F(1,73) = 0.876	0.352	Correct specification
CUSUM	Within 5% bounds		Parameters stable
CUSUMQ	Within 5% bounds		Variance stable

Source: Author's computation from post-estimation procedure

To formally asses the temporal stability of the estimated parameters, figure 2presents the CUSUM and CUSUMQ recursive residual plots.

Figure 2: CUSUM and CUSUMQ parameter stability tests



Notes: The straight dashed lines represent the 5% critical bounds. Both statistics remain within the bounds throughout 2000Q1-2025Q4, confirming parameter and variance stability.

Source: The author's estimations from NARDL model using Eviews13.

Figure 2 presents the CUSUM and CUSUMQ stability diagnostics for the estimated NARDL model. Both the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMQ) remain well within the 5% critical bounds throughout the entire sample period 2000Q1-2025Q4. The CUSUM plot exhibits no systematic drift or directional deviation, confirming the stability of the estimated parameters across all sub-periods, including the three major structural disruptions of 2008,2020, and 2022. Similarly to the CUSUMQ plot shows no abrupt variance shifts, validating the constancy of the residual variance over time. Collectively, these results confirm that the asymmetric long-run and short-run coefficients reported in tables 7 and 8 are structurally stable and not driven by any particular crisis episode. The stability of the model further reinforces the credibility of the Wald asymmetry test results presented in table 9 and supports the robustness of the policy implications derived from the NARDL estimation.

Table 11 quantifies the cumulative dynamic multiplier effects at six selected time horizons (Q1 through Q20). These values trace the progressive divergence between positive and negative shock response. By Q4, the positive food price shocks have already transmitted approximatively 77% of its long-run impact (0.268 versus the terminal 0.347), whereas the negative shocks have transmitted only 44% (0.056 versus 0.128). This numerical evidence confirms the timing asymmetry: adverse shocks are front-loaded while favorable adjustments are protracted.

Table 11. Cumulative dynamic multiplier values at selected horizons

Horizon	GFP^+	GFP^-	Asymmetry GFP	EX^+	EX^-	Asymmetry EX
Q1	0.121	−0.018	0.139	0.097	−0.011	0.108
Q4	0.268	−0.056	0.324	0.218	−0.035	0.253
Q8	0.328	−0.094	0.422	0.267	−0.061	0.328
Q12	0.341	−0.115	0.456	0.278	−0.076	0.354
Q16	0.345	−0.124	0.469	0.281	−0.085	0.366
Q20	0.347	−0.128	0.475	0.283	−0.091	0.374

Notes: values represent cumulative multiplier effects on the food import dependency ratio following a unit positive and negative shocks. The asymmetry column reports the absolute difference between positive and negative cumulative multipliers at each horizon.

Source: Author's computations from the estimated NARDL dynamic multiplier analysis.

Table 12 presents the robustness verification using an alternative PCA-based food security index as the dependent variable. The core asymmetric patterns identified in the baseline model are fully preserved: GFP+ and EX+ retain their significance and positive signs, while their negative counterparts remain weak or insignificant. The Wald tests continue to reject symmetry decisively.

These results confirm that the baseline findings are not an artifact of the specific dependent variable chosen.

Table 12. Robustness check PCA-based food security index

Variable	Baseline model (FS)	Robustness model (PCA index)
GFP^{+}	0.347*** (0.089)	0.312*** (0.094)
GFP^{-}	−0.129* (0.072)	−0.118 (0.078)
EX^{+}	0.283*** (0.076)	0.251*** (0.081)
EX^{-}	−0.094 (0.081)	−0.087 (0.086)
AGR	−0.198** (0.082)	−0.178** (0.087)
ECM (t-1)	−0.237*** (0.058)	−0.214*** (0.062)
Wald $\chi^2(GFP)$	12.467***	9.876***
Wald $\chi^2(EX)$	8.934***	7.234***

Notes: standard errors in parentheses denote significance at 1%,5% and 10%. The PCA index is constructed from standardized measures of food imports, agricultural values added, inflation and per capita output.

Source: Author's estimations. PCA index constructed from standardized food security indicators.

VII. Discussion:

All four-hypothesis derived from the integrated theorical framework are confirmed by the empirical analysis.

Table 13. Summary of hypothesis and empirical results

Hypothesis	Content	Result	Evidence
H1	Nonlinear long-run equilibrium exists	Confirmed	F=5.874>4.26 (1%)
H2	Asymmetry in food price effects	Confirmed	Waldχ^2 =12.467(p<0.01)
H3	Asymmetry in exchange rate effects	Confirmed	Waldχ^2 =8.934(p<0.01)
H4	Agricultural production mitigates food security.	Confirmed	AGR= -0.198 (p<0.05)

Source: Author's compilation.

First, the large difference between the coefficient GFP^{+} and GFP^{-} confirms the core proposition of asymmetric price transmission theory. The long run coefficient on positive global food price shocks (0.347) is nearly three times larger in absolute value than the coefficient on negative shocks (-0.129), and the latter is only weakly significant. This means that when world food prices increase, Algeria's food dependency ratio worsens sustainability, but when world prices decline, the improvement is partial and limited. This aligns perfectly with Peltzman (2000), Meyer and Von Cramon-Taubadel (2004), and Von Cramon-Taubadel (1998). Rising international prices are quickly reflected in the national import bill because the state must secure essential staples regardless of cost. Lower world prices, however, are not fully passed through due to existing contracts, subsidy mechanisms, and intermediary capture.

Second, the exchange rate results strongly support ERPT theory. The coefficient on EX^{+} is significant, while EX^{-} is statically significant, which supports Campa and Goldberg (2005). Depreciation raises domestic import costs immediately. UNCTAD (2023) highlights how trade

vulnerabilities interact intricately with such currency dynamics in commodity-dependent economies.

Third, the negative and significant coefficient on AGR (-0.198) confirms the buffering logic of Sens's approach, resonating with Devereux (2001) who critically extended Sin's framework to analyze how structural access failures rather than supply failures alone determine food insecurity outcomes. Higher agricultural output substitutes imports, strengthening macroeconomic resilience.

Fourth, the structural break dummies reveal the exceptional importance of crisis episode. The largest coefficient belongs to DUM_{2022} (4.234), suggesting that Russia-Ukraine conflict was even more damaging to Algeria's food security than the 2008 food crisis or Covid-19 pandemic. This is plausible because the 2022 episode combined grain supply disruption, fertilizer shortages, energy market volatility, and trade uncertainty simultaneously, consistent with Ben Hassen and El Bilali (2022) and Glauber and Laborde (2023). Data from Banque d'Algérie (2023) on foreign reserve depletion during this period corroborate the severity of the fiscal strain imposed by the simultaneous commodity and geopolitical shocks.

Fifth, the error correction coefficient of -0.237 indicates moderate adjustment speed. Approximatively 23.7% of any disequilibrium is corrected each quarter, implying that full adjustment requires roughly 4.2 quarters. The dynamic multiplier analysis reveals a profound timing asymmetry: adverse shocks peak within 4-6 quarters, while favorable shocks require 10-14 quarters to produce noticeable improvements. Such timing asymmetry implies prolonged exposure to welfare losses even when global conditions eventually improve. These findings are broadly consistent with Soumbara and EL-Ghini (2024) who documented asymmetric effects of climate variability on food security in Morrocco using NARDL framework, Hadj Cherif et al., (2021) for MENA economies, and Ibrahim (2015) for Malysia.

The broader implication is clear: linear policy thinking is inadequate. If policymakers assume that favorable shocks offset adverse shocks symmetrically, they will systematically underestimate cumulative vulnerability. The evidence presented in this study demonstrates that bad external news is transmitted rapidly and powerfully, while good news is weak, delayed and incomplete. This creates a structural bias toward fragility and calls for preemptive rather than reactive policy design.

VII. Policy implication:

The empirical confirmation of severe, asymmetric vulnerability dictates that Algerian policymakers cannot rely on reactive, linear or passive strategies to maintain sovereign food security. Because negative shocks inflict rapid damage while positive shocks provide little relief, a proactive, multipronged structural transformation is imperative.

Given the speed at which global price spikes damage the economy, Algeria must dramatically expand its physical silo capacity for strategic commodities durum wheat, soft wheat and powdered milk to guarantee a minimum of 12 to 18 months of domestic consumption. Such reserves would insulate would insulate the economy from short-term global volatility, providing a critical temporal buffer during which policy adjustments can be mobilized.

The large DUM_{2022} coefficient confirms the danger of concentrated supply dependence on Black Sea region. The state purchasing agency must actively diversify its suppliers base toward Latin America, North America, and Australia to mitigate the risks associated with regional supply blockades and geopolitical conflict.

As domestic production AGR is demonstrated to be the primary buffer against external shocks, the state must redirect hydrocarbon rents toward sustainable agricultural intensification. Priority areas include large-scale desalination projects for irrigation, the development and dissemination of drought-resistant seed varieties, and the deployment of precision agriculture technologies in Saharan and Hauts Plateaux regions. Such investement would reduce structural dependence on imported calories and strengthen the sovereign food entitlement base.

To combat the asymmetry of price spikes, the Algerian Ministry of Finance and state importers must deploy sophisticated financial hedging instruments futures and options contracts on international commodity exchanges (e.g., CBOT, MATIF) to lock in prices and improve the predictability of fiscal outlays. Such instruments would reduce exposure to the rapid pass-through of positive global food price shocks documented in this study.

The strong adverse effect of depreciation implies that exchange rate policy is simultaneously food security policy. The Central Bank should adopt a more strategically managed float, preventing severe sudden devaluations while aggressively building foreign exchange buffers during hydrocarbon booms. These reserves should be specifically earmarked for an agricultural stabilization fund to shield food imports from currency volatility.

Because DZD/USD exchange rate volatility serves as a dominant transmitter of external shocks with statically insignificant benefits from appreciation Algeria should leverage its geopolitical partnerships (e.g., BRICS alignment) to negotiate bilateral commodity trade agreements denominated in local currencies, EURO or the YUAN. This would reduce direct exposure to the US monetary policy and attenuate the exchange rate channel of food insecurity.

Utilizing machine learning and the asymmetric modeling frameworks demonstrated in this study, the government should establish a real time-data observatory that monitors global climate patterns, commodity futures, and currency fluctuations to preemptively trigger food security defense mechanisms before physical shortages materialize. Advances in forecasting methodologies, including abductive network approaches and related predictive techniques (Abdel Aal & Al Garni,1997), can inform the design and calibration of such systems, enabling proactive rather than reactive crisis management.

IX. Conclusion:

This study has reconceptualized intricate vulnerabilities of Algeria's macro-food system through the rigorous lens of nonlinear econometrics. By systematically applying the NARDL framework to quarterly data spanning, the research has empirically dismantled the traditional assumption of linear shocks transmission. The findings conclusively demonstrate that exogenous pressures specifically global agricultural commodity price spikes and depreciation of the Algerian dinar exert a disproportionately destructive and rapid roll-on sovereign food security, as measured by the food import security, as measured by the food imports dependency.

The long-run coefficient on positive global food price shocks is 2.69 times larger than the negative shocks. Exchange rate depreciation generates a significant coefficient of 0.283, while appreciation is statically insignificant -0.094. The Wald tests reject symmetry at the 1% level both variables in both horizons. These results are robust to an alternative PCA based food security measure and the Hatemi-J (2012) asymmetric causality framework. The error correction terme of -0.237 indicates moderate adjustment speed, and the dynamic multiplier analysis reveals that adverse shocks reach maximum impact within 4-6 quarters while beneficial shocks require 10-14 times quarters a profound timing asymmetry with far-reaching welfare implications.

The structural breaks induced by the 2008 financial collapse, the 2020 Covid-19 pandemic, and the particularly the 2022 Russa-Ukraine conflict starkly illustrate that Algeria's historical paradigm of subsidizing its was out of global crises via hydrocarbon revenues is an inherently fragile and fiscally unsustainable long-term strategy. The profound asymmetry discovered herein serves as a critical warning: the domestic economy internalizes international market distress instantly but fails to capture the benefits of market recoveries. Achieving genuine food sovereignty demands an aggressive pivot toward sustained and substantial domestic agricultural fortification and sophisticated external risk management.

While this study provides a robust macroeconomic baseline, it is not without limitations. The reliance on aggregate food dependency metrics inherently obscures the micro-level of nutritional impacts on vulnerable household deciles. Furthermore, the aggregation of global food prices into a single index masks commodity-specific dynamics that may exhibit heterogenous transmission patterns. The use of temporally disaggregated data, while methodologically justified through the Chow-Lin procedure, introduces potential measurement uncertainly that warrants acknowledgment. Future research should focus on sectoral decompositions, applying the NARDL methodology to trace the individual, asymmetric pass-through effects of specific indispensable commodities to yield even more granular and targeted policy directives. Additionally, panel NARDL analyses encompassing other North African and MENA food importing nations would enhance the generalizability of these findings and enable cross-country comparative policy design.

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