DOI: 10.28934/ea.1002 First Online: February 11, 2026

ORIGINAL SCIENTIFIC PAPER

Imports versus Domestic Production and the Food Security Dilemma in the Arab World: Evidence from a Panel CS-ARDL Approach

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ABSTRACT
This study examines the determinants of food security in a panel of eleven Arab countries over the period 2000–2023 using the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) approach. The aim is to explore both short-run dynamics and long-run equilibrium relationships affecting food self-sufficiency. The results indicate that per capita income exerts a negative effect in the short run, reflecting changing consumption patterns and greater reliance on food imports, while agricultural production emerges as the most consistent positive driver of food self-sufficiency. Short-run dynamics also confirm a rapid adjustment process, with the error correction term (ECT = –1.3569, $p < 0.01$) indicating strong and more-than-complete convergence toward equilibrium. In the long run, agricultural value added is the only variable with a robust and significant influence, underscoring the strategic importance of the agricultural sector for sustainable food security. These findings highlight the structural vulnerability of food systems reliant on imports and call for policies aimed at enhancing agricultural productivity, promoting self-reliance, and reducing exposure to volatile international food markets.

Keywords: *food security, food self-sufficiency, ariculture, imports, CS-ARDL approach, Arab countries*

JEL Classification: C33, O13, Q17, Q18

INTRODUCTION

Food insecurity, famine, and malnutrition remain persistent global challenges, with profound implications for human health, productivity, and long-term development outcomes. FAO, IFAD, UNICEF, WFP, & WHO (2023) note that chronic undernutrition weakens human capital formation, reduces labor productivity, and perpetuates cycles of poverty and vulnerability. In this context, the concept of food security has gradually evolved from a narrow focus on food availability to a multidimensional framework encompassing availability, economic and physical access, utilization, and stability over time. Countries differ markedly in how these dimensions are

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achieved and balanced, depending on resource endowments, demographic pressures, and exposure to external shocks.

Agricultural development is widely recognized as a cornerstone for improving food security and nutrition (FSN), not only by expanding the quantity and diversity of food supply but also by serving as a driver of structural transformation and inclusive economic growth. HLPE (2016) highlights that agriculture continues to represent the primary source of income for the majority of rural populations, particularly the 1.3 billion people who depend on it directly for their livelihoods, thereby linking agricultural performance directly to food security outcomes. Christiaensen, Demery, & Kuhl (2011) and Kidane, Maetz, & Dardel (2006) emphasize that agriculture can serve as an engine of sustained economic growth, especially in the early phases of development. More recent studies reinforce this perspective, with FAO (2021) and World Bank (2022) noting that investments in agricultural productivity, resilience, and value chains are fundamental not only for achieving Sustainable Development Goal 2 ("Zero Hunger") but also for ensuring broader economic transformation in developing regions.

At the same time, many countries increasingly rely on food imports to close the gap between domestic demand and local production. Imports can play a positive role by compensating for structural constraints such as land and water scarcity, by smoothing domestic supply in the face of climatic shocks, and by enabling consumers to access a more diversified food basket. For resource-rich or highly open economies, food imports may also be a rational strategy to reallocate scarce factors of production toward sectors with higher comparative advantage. However, heavy dependence on imports exposes countries to world market volatility, exchange rate fluctuations, export restrictions from trading partners, and rising geopolitical risks. In periods of global crises, international markets may not always serve as a reliable buffer, thereby amplifying domestic food insecurity.

By contrast, domestic agricultural production contributes to food security through multiple channels: it increases local availability, supports rural incomes, and can strengthen national resilience to external shocks. Yet, in many developing regions, including the Arab world, raising domestic production is constrained by biophysical limits (arid climate, water scarcity, limited arable land), institutional weaknesses, and underinvestment in rural infrastructure and agricultural R&D. As a result, most countries face a food security dilemma: "How do food imports and domestic agricultural production jointly affect food security in Arab countries, and what are the short-run and long-run implications for food self-sufficiency?"

United Nations (2022) project that the global population will surpass 9 billion by 2050, with the most pronounced demographic expansion occurring in developing countries across Africa and Asia. For the Arab world, this demographic pressure is compounded by structural food deficits, rapid urbanization, high unemployment, and acute water scarcity. Meeting the resulting demand for food requires not only faster growth in total supplies but also careful management of the balance between imports and domestic production in order to prevent further tightening of global and regional food markets. Herrmann (2009) notes, however, that food insecurity is often not prioritized adequately in policy agendas, partly because emergency food aid and international trade are assumed to offset short-term shortages, and partly because food security is a multidimensional concept that is inherently difficult to measure and to incorporate into coherent policies. Boussard, Gérard, & Piketty (2006) argue that this has frequently relegated agriculture to a secondary role in national development strategies, especially in oil-exporting or import-dependent economies.

The Arab world provides a particularly relevant setting for examining this trade-off between imports and domestic production. On the one hand, many Arab countries are among the most food-import-dependent economies in the world, especially for cereals and other staple foods. On the other hand, the region is characterized by severe natural resource constraints, high exposure to climate change, and recurrent political and economic shocks. These shared structural features justify treating the Arab world as a meaningful analytical group, while the heterogeneity in income

levels, resource endowments, and policy choices across the countries included in our sample offers sufficient variation to identify the differential roles of imports and domestic production in shaping food security outcomes.

Against this background, the present paper, titled "Imports versus Domestic Production and the Food Security Dilemma in the Arab World: Evidence from a Panel CS-ARDL Approach", seeks to empirically assess how food imports and domestic agricultural production jointly affect food security in a panel of Arab countries. Using a cross-sectionally augmented ARDL (CS-ARDL) framework, we investigate both the short-run and long-run impacts of these two channels on food security indicators, while explicitly accounting for cross-sectional dependence and heterogeneity across countries. By doing so, the study aims to provide evidence-based insights into how Arab countries can navigate the imports–production trade-off in order to enhance their food security in an increasingly uncertain global environment.

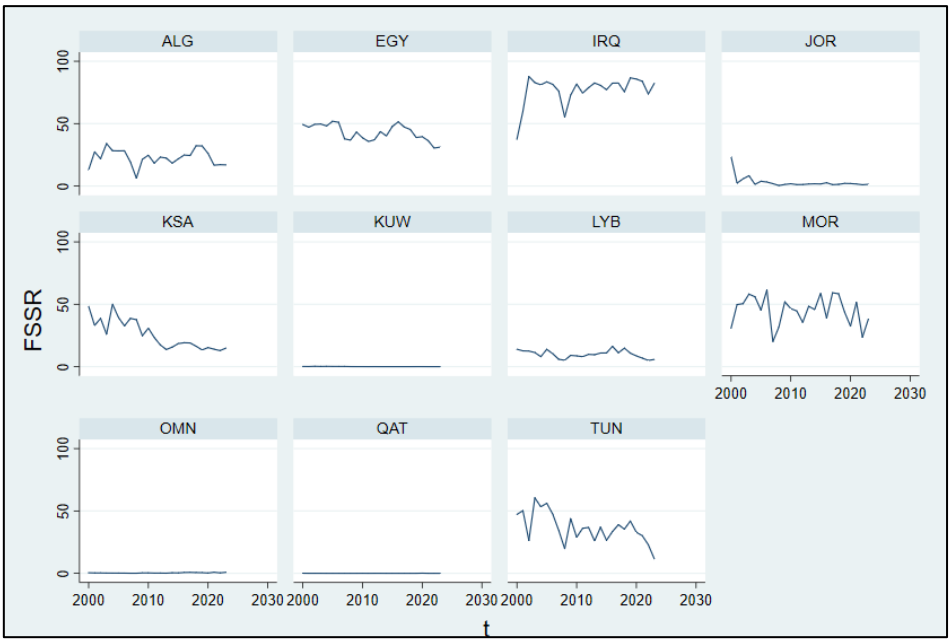

Figure 1. Evolution of Wheat Self-Sufficiency in Arab Countries (2000–2023)

Source: Stata 15 software output

As shown in Figure 1, the analysis of Food self-sufficiency ratios (Wheat FSSR) in eleven Arab countries during the period 2000–2023 reveals clear structural differences between agrarian and resource-dependent economies. Morocco and Algeria achieved relatively higher wheat self-sufficiency levels, often exceeding 40% in several years (e.g., Morocco 61.4% in 2006; Algeria 33.9% in 2003), reflecting the stronger role of domestic agriculture in meeting wheat demand. By contrast, Gulf economies such as Kuwait and Qatar remained almost entirely import-dependent, with Wheat FSSR values close to zero (below 0.3% throughout the period), highlighting the structural constraints of local production under severe water and land scarcity. Egypt and Tunisia, despite their agricultural traditions, experienced downward trends: Egypt's Wheat FSSR declined from about 49% in 2000 to nearly 31% in 2023, while Tunisia fell sharply from above 50% in the early 2000s to only 11.7% in 2023, reflecting demographic pressures and insufficient agricultural investment. Saudi Arabia clearly illustrates the income–import nexus, as its Wheat FSSR dropped from 48% in 2000 to below 15% after 2020, driven by rising incomes and a shift in demand toward higher-value imported food products. Iraq, on the other hand, maintained relatively high levels often above 75% despite conflict and instability, due to its strong reliance on wheat as a staple crop. Overall, these patterns underscore that wheat production capacity remains the

cornerstone of sustainable food security in some Arab states, while rising incomes, demographic expansion, and resource dependence systematically erode self-sufficiency and leave the region highly exposed to volatility in global wheat markets.

LITERATURE REVIEW

A growing body of literature highlights the complex interlinkages between food security, agricultural development, and economic performance in developing countries. Using a dynamic panel of 75 dryland economies between 1970 and 2016, Manap & Ismail (2019) applied the Generalized Method of Moments (GMM) and found that improvements in food security significantly stimulate economic growth, both directly and indirectly, through higher life expectancy, greater employment opportunities, and poverty reduction. Their findings confirm that food security contributes not only to human capital accumulation but also to macroeconomic performance. Sun & Zhang (2021), using panel data for Central Asian countries from 2001 to 2018 and employing the four pillars of food security, examined the impact of trade openness and other determinants on food security using a fixed-effects model, supported by robustness tests through pooled LS and dynamic panel GMM approaches. The findings indicate a U-shaped relationship between trade openness and food security, suggesting that food security improves once trade openness surpasses a certain threshold. The study also shows that GDP per capita, GDP growth, and agricultural productivity positively enhance food security, whereas agricultural employment, arable land constraints, freshwater withdrawals, population growth, natural disasters, and inflation exert negative effects. Overall, the evidence confirms that trade policy reforms contribute to strengthening food security in Central Asia, while maintaining reasonable levels of food self-sufficiency remains crucial due to potential risks associated with global trade dependence. Dekkiche, Saidi, & Cherayett (2025) investigate food security in developing Arab and African countries from 1990 to 2023 using the Panel-ARDL model. The findings show that despite having significant agricultural labor and arable land, food production remains insufficient due to rapid population growth, forcing many countries to rely on food imports and exposing them to global price and supply shocks, especially during crises such as the Russia–Ukraine conflict. The study recommends strengthening the agricultural sector through increased investment, promoting regional trade, and adopting modern technologies such as digital agriculture, artificial intelligence, and smart irrigation. It further highlights the need for regional and global cooperation to ensure stable access to essential food resources. Ngassam, Douanla, & Asongu (2025) analyze the impact of natural resources on food import dependence across 38 sub-Saharan African countries from 2000 to 2020. The findings indicate that resource-dependent countries tend to over-rely on food imports, with oil and gas rents increasing dependence while mineral rents reduce it. Importantly, liberal, egalitarian, deliberative, and electoral democracies can mitigate the effect of natural resources on food import dependence. The study highlights the need for African governments to rethink food policy strategies, suggesting that revenues from natural resources be invested in agricultural infrastructure and that democratic institutions be strengthened to reduce reliance on imported food.

Also, Akramov & Shreedhar (2012) examined Tajikistan in the aftermath of global food and economic crises and documented how macroeconomic shocks and price volatility undermined both national and household food security. Their study stressed the importance of policy instruments to mitigate the effects of external shocks, including sectoral diversification and social protection systems. Similarly, Herrmann (2009) emphasized that although high food prices could potentially stimulate agricultural development, market imperfections and weak transmission of international prices to local producers often prevent such benefits from materializing. This underscores the need for complementary measures such as credit access, infrastructure, and input support to enable producers to respond effectively to price signals .Rezgar and Almojel (2025) analyze the income and price elasticities of imported food demand across Arab countries using the static Almost Ideal Demand System (AIDS) model and find that most essential food

imports exhibit inelastic demand, implying that consumption remains relatively stable despite price fluctuations. However, this structural dependence on imports increases exposure to external shocks, prompting the need for government interventions such as subsidies and taxation to stabilize domestic markets.

Building on this import-dependence perspective, recent panel evidence suggests that vulnerability extends beyond consumption behavior to broader structural price dynamics. Dardeer and Shaheen (2025) show that higher food import dependence and urbanization significantly intensify food price volatility in GCC countries, whereas improvements in domestic agricultural productivity and employment contribute to greater price stability and enhanced food security. Similarly, Fan et al. (2024) demonstrate that although agricultural trade openness may improve food availability in the short run, excessive reliance on imports undermines long-term food security by increasing exposure to external price and supply shocks, while stronger domestic production capacity enhances resilience.

Beyond this import–production dichotomy, a growing strand of literature highlights the importance of supply diversification and systemic risk management. Deteix, Salou, and Loiseau (2024) develop food supply risk indicators that integrate both domestic production capacity and the diversity of import sources. Their cross-country analysis shows that countries dependent on a limited number of suppliers face greater vulnerability to disruptions, and that food self-sufficiency alone does not necessarily reduce risk. Instead, resilient food systems require a balanced strategy combining strengthened local production with diversified and stable trade linkages.

Research on sub-Saharan Africa also provides valuable insights. Ofana, Charles, & Eko (2016), using time series econometrics for Nigeria (1970–2010), identified rainfall, exchange rates, and lagged food exports as positive drivers of agricultural output, while food imports, diversion of agricultural funds, and limited technology diffusion acted as major constraints. In the same context, Agwu, Dimelu, & Madukwe (2008) argued for stronger institutional support for agricultural innovation, recommending that governments create incentive structures and extension systems that align research outputs with farmers' realities. Evidence from Gauchan (2008) in Nepal further illustrates the contribution of agriculture to food security, poverty reduction, and overall economic growth, while also highlighting challenges in trade integration, distribution systems, and structural weaknesses that limit the sector's transformative role. Barel Shaked & Buda (2025) examine food self-sufficiency ratios (SSR) in 38 OECD countries from 2010 to 2021, analyzing their relationship with economic growth and external dependencies. Using FAO data and a stratified sampling approach, countries were classified into six typologies based on SSR and GDP per capita, and statistical analyses, including mean comparisons and T-tests, were applied. The findings reveal that wealthier European nations tend to have lower SSRs and rely heavily on food imports, while less affluent countries exhibit higher self-sufficiency, prioritizing local production as a resilience strategy. By focusing on food categories rather than aggregate SSRs, the study offers a nuanced understanding of self-sufficiency trends and highlights areas of high external dependency. The research underscores the importance of economic and agricultural policy reforms to enhance national resilience and reduce vulnerabilities in global food markets, despite limitations related to data coverage and the exclusion of recent global disruptions.

More recent contributions have extended this debate by linking food security to climate change, demographic dynamics, and the water–energy–food nexus. For example, Derouez & Adel (2024) examined five Arab countries spanning 1990–2022 and demonstrated that population growth and climate change pressures necessitate integrated policy frameworks combining renewable energy, desalination, and sustainable agricultural practices. Similarly, a recent panel study in West Africa Frimpong, Mintodê, & Tony (2024) show no significant link between CO2 emissions and economic growth, while agriculture plays a key role, and food availability has mixed effects. Segbefia et al. (2023) investigated the impact of carbon emissions, population growth, economic growth, and human capital on food security across five African countries (Nigeria, Ghana, Kenya, Zimbabwe,

and Tanzania) using panel data from 1990 to 2021. It also assessed the moderating role of human capital in the relationship between carbon emissions and food security. Preliminary tests confirmed cross-country interdependence, stationarity, and cointegration among the variables. Using the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) model, the study found that carbon emissions and population growth negatively affect food security, while human capital and economic growth enhance it. Additionally, the results showed that human capital moderates the relationship between carbon emissions and food security, indicating that strengthening human capital can mitigate the adverse effects of emissions on food security. Causality analysis revealed a unidirectional relationship running from economic growth, population growth, and human capital to food security, along with a bidirectional causal link between carbon emissions and food security. Overall, the findings contribute new evidence to the literature on the food security–environment nexus and highlight the importance of investing in human capital to reinforce the interaction between carbon emissions and food security in African countries. Ceesay & Ndiaye (2022) aimed to examine the impact of climate change on food security, along with other key variables such as economic growth, population growth, and the agricultural sector, using annual data for the period 1971–2020. The authors employed several modern econometric techniques, including the Vector Autoregressive (VAR) model, Granger Causality tests, the Autoregressive Distributed Lag (ARDL) model, and the Error Correction Model (ECM). The empirical findings revealed that food security growth is strongly and positively correlated with the agricultural sector, while it shows a negative relationship with rainfall variability. In addition, the results indicated that population growth has a significant negative effect on food security in the short run, whereas its long-run effect is negative but statistically insignificant.

The findings underscore the importance of sustainable agriculture and food security in promoting economic resilience in West Africa, offering insights for policymakers. The FAO, IFAD, UNICEF, WFP, & WHO (2023) SOFI report also confirms that progress toward "Zero Hunger" is stagnating globally, with the affordability of healthy diets deteriorating, thereby reinforcing the urgency of productivity, resilience, and value-chain–oriented policies. Taken together, these studies converge on the conclusion that food security is both a driver and an outcome of sustainable economic development. While short-term shocks and external dependencies undermine stability, long-run improvements hinge on agricultural productivity, institutional capacity, and integrated strategies that address the multidimensional nature of food systems.

DATA AND METHODOLOGY

Econometric Approach and Estimation Strategy

This section covers the empirical approach, potential problems with the estimating processes, and our solutions to these problems. To know the impact of food security determinants in the Arab region, we employ panel data. There are well-established advantages to researching this topic with panel data. One significant benefit is that the degrees of freedom increase when both time and unit components are included, and the outcomes are less susceptible to changes in the model specification. Furthermore, the large sample properties linked to panel data contribute to better model estimates, and problems related to measurement error, reverse causality, endogeneity, and omitted variables are considerably minimized. where the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) approach, proposed by Chudik and Pesaran (2015), belongs to the second generation of panel econometric methods. Unlike traditional ARDL models, Pesaran & Smith (1995), CS-ARDL accounts for cross-sectional dependence and slope heterogeneity by incorporating cross-sectional averages of the variables in the estimation. This framework makes it robust in dealing with common shocks and interdependencies across units, such as countries in a panel dataset Chudik & Pesaran (2015). The theoretical foundation begins with the standard Panel ARDL framework, which provides the basis

for modeling both short-run dynamics and long-run equilibrium relationships in heterogeneous panels. Building on this, the analysis extends to the more advanced Panel CS-ARDL approach, which augments the traditional specification to account for cross-sectional dependence through cross-sectional averages, thereby offering more consistent and reliable estimates in the presence of common shocks. This method is particularly suitable for food security studies in the Arab region, where shocks in one country often spill over to others due to economic, social, and trade linkages. More specifically, the cross-sectionally augmented ARDL regressions are given by:

Before presenting the cross-sectionally augmented ARDL in detail, it is useful to recall the original Panel ARDL specification introduced by Pesaran & Smith (1995) and further developed by Pesaran et al. (1997). The general formulation of the Panel ARDL model (p, q) was as follows:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \hat{\delta}_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (1)$$

Where Xit (k X 1) is a vector of explanatory variables, which varies across both time periods and cross-sectional units. The value of T should be sufficiently large to allow for estimating the model for each group. However, it is not necessary for T to be the same for each group. For the sake of simplicity in notation, we will assume a common value for T. It is also straightforward to allow for different lag orders on the different variables in Xit. The coefficients of the lagged dependent variables, λ_ij, are scalars, and δ`_ij is K X 1 vectors of unknown parameters.

It is convenient to work with the following re-parameterization (1): Blackburne & Frank (2007)

$$\Delta y_{it} = \theta_i \left(y_{i,t-1} - \hat{\theta}_i X_{it} \right) + \sum_{j=1}^{p-1} \lambda_{ij}^{*} \Delta y_{i,t-1} + \sum_{j=1}^{q-1} \hat{\delta}_{ij}^{*} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (2)$$

The parameter $\theta_i = -1 - \sum_{j=1}^{p} \lambda_{ij}$ is the error-correcting speed of adjustment term. It should be less than zero (θ<0); and if θ = 0, then there would be no evidence for a long-run relationship. This parameter is expected to be significantly negative under the prior assumption that the variables show a return to long run equilibrium. The vector θ`_i ′ contains the long run relationship of the variables Shuaibu & Popoola (2016).

But if the errors ε_{it} contain unobserved common factors with heterogeneous loadings, standard ARDL estimators become biased and inconsistent. This problem arises in panels with global shocks, regional spillovers, or strong interdependencies across cross-sections. Pesaran (2004, 2006) proposed the CD test to detect (2004) such dependence and developed the Common Correlated Effects (CCE) estimator to account for unobserved common factors. The expanded form of the traditional model can include extra lags (r) to the ARDL specification as follows.

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \hat{\delta}_{ij} x_{i,t-j} + \sum_{j=0}^{r} \beta_{ij} \theta \, \bar{M}_{t-1} + \mu_i + \varepsilon_{it} \quad (3)$$

Where $\bar{M}_{t-1} = (\bar{X}_{i,t-k}, \bar{Y}_{i,t-k})$ is the cross-section average of regressed, and it eliminates cross-section dependencies. We can transform Equation (3) to an ECM to decompose short and long-run effects. At that, we come up with the following CS-ARDL specification.

$$\Delta y_{it} = \theta_i \left(y_{i,t-1} - \hat{\theta}_i X_{it} \right) + \sum_{j=1}^{p-1} \lambda_{ij}^{*} \Delta y_{i,t-1} + \sum_{j=1}^{q-1} \hat{\delta}_{ij}^{*} \Delta X_{i,t-j} + \sum_{j=0}^{r} \beta_{ij} \bar{M}_t + \mu_i + \varepsilon_{it} \quad (4)$$

Equation (4) indicates the ECM presentation of the Panel CS-ARDL approach. Δ is the difference operator with an optimal lag order, $\lambda_{ij}^{*} = -\sum_{m=j+1}^{p} \lambda_{im} \, (j = 1,2, \ldots . p-1)$and $\hat{\delta}_{ij}^{*} = -\sum_{m=j+1}^{q} \lambda_{im} \, (j = 1,2, \ldots q-1)$ are the short run coefficients, $\theta_i = -(1 - \sum_{j=1}^{P} \lambda_{ij})$is the errorcorrection term. This term indicates the speed of adjustment toward long run equilibrium after a shock to the system. This term should be statistically significant and negative to support

the long-run equilibrium. $\grave{\theta}_i = (\sum_{j=0}^{q} \beta_{1i}) / \theta_i$ is the long run coefficient. For the calculation of the variance/covariance matrix of the individual long-run coefficients θi the delta method used the vector of the long run coefficient . $\bar{M}_t$ the cross-sectional averages of the dependent variable and the explanatory variables at time t .Yilmaz (2024).

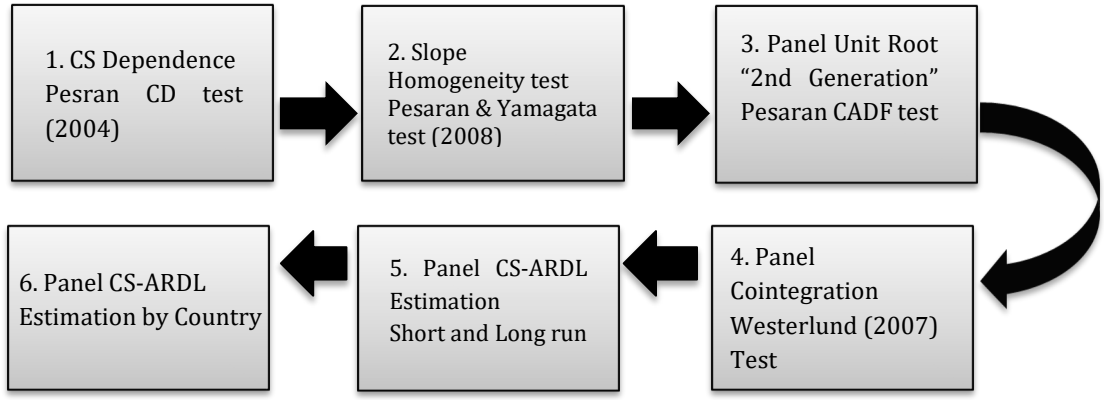

Figure 2. Steps in econometric approach

Source: Authors' elaboration

Empirical Model

As illustrated in Figure 2, this study aims to analyze the determinants of food security in 11 Arab countries over the period 2000–2023 using the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) approach, which distinguishes between short-run dynamics and long-run relationships in panel data while explicitly accounting for cross-sectional dependence. The sample comprises Jordan, Algeria, Morocco, Oman, Egypt, Saudi Arabia, Kuwait, Iraq, Tunisia, Qatar, and Libya.

Food self-sufficiency ratio (FSSR), sourced from FAO, serves as the dependent variable, while the independent variables include agricultural production (VAGR), GDP per capita (GDPPC), population (POP), and food imports (FIG). The baseline model for the variables in the study may be noted as follows:

$$FSSR = f(VAGR, POP, GDPPC, FIG) \quad (5)$$

Data Sources, Variables and Measurement

Data were collected from FAO and WDI. For consistency and econometric robustness, the natural logarithm (ln) transformation was applied to all continuous independent variables, whereas FSSR remains expressed as a percentage.

Table 1. Variables, source and measurement

Variable	Code	Measurement	Source
Food Security (dependent)	FSSR	Food Self-Sufficiency Ratio (%)	FAO
Agricultural Production	VAGR	Natural log value added in the agricultural sector (constant US$)	WDI
GDP per capita	GDPPC	Natural log of GDP per capita (constant US$)	WDI
Population	POP	Natural log of total population	WDI
Food Imports	FIG	Natural log of food imports value (constant US$)	FAO

Source: Authors' elaboration

Descriptive Statistics of the Study Variables

Table 2 presents the descriptive statistics for the core variables examined in this study, covering 11 Arab countries during the period 2000–2023. The statistics include the mean, standard deviation, minimum and maximum values, and the number of observations. This descriptive analysis provides a preliminary understanding of the distribution and variation of the dataset before proceeding with advanced econometric modeling using the Panel CS-ARDL approach.

Table 2. Descriptive Statistics

Statistic	FSSR	VAGR	POP	FIG	GDPPC
Mean	23.93	21.74	15.98	15.45	3.88
Standard Deviation	24.79	1.67	2.05	0.74	0.50
Minimum	0	17.72	6.39	14.08	2.91
Maximum	87.83	24.67	18.29	17.10	5.03
Observations (N)	264	262	264	264	264

Source: Stata 15 software output

The descriptive results highlight substantial variation across countries and variables. The food self-sufficiency ratio (FSSR) shows a low average of 23.93 with a high dispersion, signifying large disparities in reliance on domestic production. Agricultural production (VAGR) averages 21.75, with relatively low variability, suggesting more stability in this sector. Population (POP) exhibits wide differences, reflecting demographic diversity among Arab countries. Food imports (FIG) also display consistent reliance on external sources, while GDP per capita (GDPPC) indicates heterogeneous income levels, spanning from low- to high-income economies. These descriptive insights underscore the structural differences within the region and set the stage for deeper econometric analysis using Panel CS-ARDL.

Cross-Sectional Dependence Test Results

Before conducting panel data estimations, it is crucial to verify whether the variables exhibit cross-sectional dependence. Cross-sectional dependence implies that shocks affecting one country may also influence others, which is common in regional studies where countries are interconnected economically, socially, and politically. Ignoring such dependence can lead to biased and inconsistent results in panel data models.

Table 3 presents the results of Pesaran's (2004) CD test for cross-sectional dependence. This test examines the null hypothesis of cross-sectional independence against the alternative of cross-sectional dependence. The test statistic follows an asymptotic standard normal distribution. Significant test results (p-value < 0.05) indicate the presence of cross-sectional dependence. Pesaran (2004).

Table 3. Pesaran (2004) Cross-Sectional Dependence Test

Variable	CD-test	p-value	corr	abs(corr)
FSSR	6.15	0.00	0.16	0.30
VAGR	28.20	0.00	0.77	0.77
POP	35.28	0.00	0.97	0.97
FIG	33.45	0.00	0.92	0.92
GDPPC	28.67	0.00	0.78	0.78

Source: Stata 15 software output

The Pesaran (2004) CD test results clearly reject the null hypothesis of cross-sectional independence for all variables under study (p-values = 0.00). This indicates that cross-sectional dependence exists among the 11 Arab countries across the period 2000–2023.

- For FSSR, the CD statistic (6.15) and moderate correlation (0.16) suggest some dependence in food self-sufficiency trends.
- For VAGR, POP, FIG, and GDPPC, the very high-test statistics (ranging from 28.20 to 35.28) and strong correlations (above 0.77, and as high as 0.97 for population) indicate substantial interdependence. This implies that changes in agricultural production, population growth, food imports, and income levels in one country are strongly linked to developments in others.
- These results confirm the existence of strong regional spillovers in food security determinants across Arab countries. Accordingly, the presence of cross-sectional dependence highlights the necessity of employing second-generation econometric methods, such as CS-ARDL, to obtain robust and unbiased results.

Slope Homogeneity Test Results

Table 4 reports the results of the slope homogeneity test developed by Pesaran and Yamagata (2008). The null hypothesis assumes that slope coefficients are homogeneous across cross-sectional units, while the alternative indicates heterogeneity. Rejecting the null implies that the relationship between variables differs significantly across countries, which has important implications for econometric modeling (Yamagata & Pesaran, 2008).

Table 4. Slope homogeneity test

Statistic	Value	p-value
Delta	9.37	0.00
Adj. Delta	10.83	0.00

Source: Stata 15 software output

The test strongly rejects the null hypothesis of slope homogeneity at the 1% significance level. This indicates that the slope coefficients are heterogeneous across the Arab countries in the sample. The result highlights the necessity of using econometric methods, such as CS-ARDL, that account for both cross-sectional dependence and heterogeneous slope parameters. This ensures that country-specific dynamics are appropriately captured rather than imposing a uniform relationship across all panels.

Second-Generation Unit Root Test Results (Pesaran CADF)

To test the stationarity properties of the panel series under cross-sectional dependence, Pesaran's (2007) Cross-sectionally Augmented Dickey-Fuller (CADF) test is applied. This second-generation unit root test augments the standard ADF regression with cross-sectional averages to control for common factors across countries. The null hypothesis assumes non-stationarity (unit root), while the alternative suggests stationarity. The test is conducted at levels and first differences Pesaran (2007) .

Table 5. Pesaran CADF Unit Root Test Results

Variable	Level (p-value)	First Difference (p-value)
FSSR	0.00 (trend); 0.00 (constant)	Stationary at level
VAGR	0.41 (trend); 0.24 (constant)	0.00 (trend); 0.00 (constant) → Stationary after first difference
GDPPC	0.00 (trend); 0.00 (constant)	Stationary at level
FIG	0.00 (trend); 0.00 (constant)	Stationary at level
POP	0.00 (trend); 0.00 (constant)	Stationary at level

Source: Stata 15 software output

All variables are integrated of order I(0) except for agricultural production (VAGR), which is I(1). This combination of stationary and non-stationary variables justifies the application of panel cointegration techniques, such as Westerlund (2007) and dynamic estimators like CS-ARDL, to analyze long-run relationships among food security determinants.

Westerlund (2007) Panel Cointegration Test Results

In the presence of cross-sectional dependence, traditional cointegration tests may lead to biased results. To overcome this limitation, Westerlund (2007) proposed error-correction based panel cointegration tests that are robust to cross-sectional dependence through the use of bootstrapping procedures. These tests examine the null hypothesis of no cointegration against the alternative that the variables are cointegrated. Four test statistics are provided: Gt and Ga (group-mean statistics), and Pt and Pa (panel statistics).

Table 6. Westerlund (2007) Panel Cointegration Test

Statistic	Value	P-value
Gt	-5.03	0.00
Ga	-10.99	0.30
Pt	-10.30	0.00
Pa	-4.89	0.71

Source: Stata 15 software output

The Westerlund (2007) cointegration test results provide mixed evidence regarding the existence of a long-run equilibrium relationship among food self-sufficiency (FSSR), agricultural production (VAGR), population (POP), food imports (FIG), and GDP per capita (GDPPC) across the 11 Arab countries.

- The group-mean test Gt is highly significant (p-value = 0.00), strongly rejecting the null of no cointegration. This indicates that at least some countries in the sample exhibit long-run relationships among the studied variables.
- The group-mean test Ga is insignificant (p-value = 0.30), suggesting weaker evidence of cointegration when using this statistic.
- The panel statistic Pt is also highly significant (p-value = 0.00), confirming the existence of cointegration at the panel level.
- The panel statistic Pa is insignificant (p-value = 0.71), which does not support cointegration according to this measure.

Overall, the results imply that there is strong evidence of cointegration when using the Gt and Pt statistics, indicating that food security determinants and food self-sufficiency share a long-run equilibrium relationship in the Arab region. However, the insignificance of Ga and Pa suggests that the evidence is not uniform across all tests. Thus, while cointegration is present, it may vary in strength and consistency across different countries.

CS-ARDL Estimation Results

This section focuses on a panel of 11 Arab countries in order to examine the determinants of food security over the period 2000–2023. The cross-sectionally augmented autoregressive distributed lag (CS-ARDL) Chudik & Pesaran (2015) approach is employed to capture both the short-run dynamics and long-run equilibrium relationships between the key variables affecting food self-sufficiency. Table 7 presents the empirical estimation results of this model, highlighting the role of the main drivers of food security across the selected countries. The estimation results presented here are based on a PANEL CS-ARDL model, which is a Cross-Sectionally Augmented Autoregressive Distributed Lag model. In this model:

The dependent variable (food self-sufficiency) is expressed in percentage terms.

The independent variables (agricultural production, GDP per capita, population, food imports) are expressed in natural logs.

This setup implies that the model is a lin-log specification (linear-logarithmic). Therefore, each coefficient reflects the absolute change in the dependent variable (food self-sufficiency) for a 1% change in the independent variable.

Table 7. CS-ARDL Estimation Results for Food Security (FSSR)

Variable	Coef.	Std. Err.	z	p-value	Variable	Coef.	Std. Err.	z	p-value
Short-run Estimates					**Long-run Estimates**				
L.FSSR	-0.35	0.12	-2.85	0.00	**lr_FIG**	20.01	17.49	1.14	0.25
GDPPC	-74.38	35.84	-2.07	0.03	**lr_GDPPC**	-80.66	54.71	-1.4	0.14
POP	60932.66	50686.18	1.20	0.22	**lr_POP**	711.21	470	1.51	0.13
FIG	-0.21	8.17	-0.03	0.97	**lr_VAGR**	32.09	15.58	2.06	0.03
ΔVAGR	22.39	10.64	2.10	0.03	**ECT (lr_FSSR)**	-1.35	0.12	-10.8	0.00
L.ΔVAGR	9.75	4.84	2.01	0.04	**R^2 (MG)**	0.74			
L.GDPPC	9.62	17.16	0.56	0.57	**N of obs**	229			
L.POP	-60225.1	50189.51	-1.20	0.23	**N of Grps**	11			
L.FIG	14.37	7.98	1.80	0.07					

Source: Stata 15 software output

The CS-ARDL estimations provide robust evidence on the determinants of food self-sufficiency, shedding light on both short-run dynamics and long-run structural relationships.

Short-Run Dynamics:

Error Correction Term (ECT):

The ECT = -1.35 ($p < 0.01$) is highly significant, indicating a rapid and stable adjustment process in the short run. The large negative value means that deviations from equilibrium are corrected by more than 100% in the subsequent period. This strong convergence indicates that the food security system is resilient to short-term shocks.

GDP per Capita (GDPPC):

The coefficient GDPPC = -74.38 ($p < 0.05$) shows a negative and statistically significant effect on food self-sufficiency in the short run. This suggests that higher income leads to greater dependence on food imports, thereby reducing domestic food production and eroding self-reliance.

Agricultural Production (ΔVAGR, L.ΔVAGR):

ΔVAGR = 22.39 ($p < 0.05$): A 1% increase in agricultural production leads to a 22.39 percentage points increase in food self-sufficiency, reflecting a positive and significant contribution of agricultural production to food security in the short run.

L.ΔVAGR = 9.75 ($p < 0.05$): Similarly, lagged agricultural production changes have a positive and significant effect. This indicates that past agricultural performance continues to impact food self-sufficiency in the short run.

Food Imports (L.FIG):

L.FIG = 14.37 ($p \approx 0.07$) shows a marginally significant effect in the short run. This suggests a substitution mechanism between food imports and domestic agricultural output, although the effect does not persist in the long run.

Long-Run Equilibrium:

Agricultural Value Added (lr_VAGR):

The long-run coefficient for agricultural value added (lr_VAGR = 32.09, $p < 0.05$) is positive and statistically significant, reinforcing the importance of agriculture in sustaining food security. This means that in the long run, agricultural growth is the key driver of food self-sufficiency.

GDP per Capita (lr_GDPPC):

The coefficient for GDPPC (lr_GDPPC = -80.66, $p > 0.05$) is not statistically significant in the long run. This suggests that, while higher incomes may influence short-term fluctuations, they do not affect food self-sufficiency in the long run.

Population (lr_POP):

lr_POP = 711.21 ($p > 0.05$) also shows no long-term statistical significance. This implies that while demographic factors may contribute to short-term variability, they do not fundamentally affect long-term food security outcomes.

Food Imports (lr_FIG):

The coefficient for lr_FIG = 20.01 ($p > 0.05$) does not achieve significance, indicating that food imports do not have a long-term effect on food self-sufficiency in the selected countries.

CS-ARDL Results by Country (Short-Run and Long-Run)

This table summarizes the CS-ARDL estimation results for each country in the sample. The reported coefficients are rounded to one decimal place, and only statistically significant variables are highlighted with an asterisk (*). The table distinguishes between short-run and long-run effects.

This means that the dependent variable (food self-sufficiency ratio, FSSR) is expressed in percentage terms, while the independent variables (agricultural production, GDP per capita, population, food imports) are expressed in natural logs. This implies that each coefficient reflects the absolute change in the dependent variable for a 1% change in the independent variable.

Table 8. CS-ARDL Estimation Results by Country

Country	Short-run Significant Effects	Long-run Significant Effects
JOR	L.FSSR -1.1*, POP -57.0*, D. VAGR 44.7*, 118.0*, LD. VAGR 35.4*, L. GDPPC 0.3*, L.FIG 87.2*	lr_GDPPC 0.5*, lr_VAGR 48.2*, lr_FIG -0.9*
ALG	FIG -61.2*, D. VAGR 44.7*, LD. VAGR 35.4*	lr_VAGR 48.2*
MOR	D.VAGR 118.0*, LD. VAGR 45.5*	lr_VAGR 163.1*
OMN	No significant short-run effects	No significant long-run effects
EGY	FIG -22.4*	No significant long-run effects
KSA	L.GDPPC -100.1*, L.FIG 87.2*	No significant long-run effects
KUW	No significant short-run effects	No significant long-run effects
IRQ	LD. VAGR 10.0*	No significant long-run effects
TUN	No significant short-run effects	No significant long-run effects
QAT	POP -0.1*, D. VAGR -0.2*, LD. VAGR -1.1*, L. GDPPC 0.3*, L.POP 0.01*, L.FIG -0.4*	lr_GDPPC 0.5*, lr_VAGR -1.1*
LYB	No significant short-run effects	No significant long-run effects

Source: Stata 15 software output

The CS-ARDL estimation results reveal that the determinants of food security, measured by the food self-sufficiency ratio (FSSR), vary substantially across the Arab world, reflecting structural differences between agrarian and resource-dependent economies. In Jordan, food security is negatively affected in the short run by population growth (POP = –57.0), while agricultural activity exerts a strong positive influence (D. VAGR = 44.7; LD. VAGR = 35.4).

Food imports contribute positively in the short run (L.FIG = 87.2), but their effect turns negative in the long run (lr_FIG = –0.9), indicating that reliance on imports may temporarily fill supply gaps but undermines sustainable self-sufficiency. In Algeria, food imports strongly reduce food security in the short run (FIG = –61.2), while agriculture exerts a significant positive effect both immediately (D. VAGR = 44.7; LD. VAGR = 35.4) and in the long term (lr_VAGR = 48.2), underscoring the centrality of domestic production in strengthening food security.

In Morocco, agriculture emerges as the most powerful driver of food security, with very strong positive effects in the short run (D. VAGR = 118.0; LD. VAGR = 45.5) and an even larger impact in the long run (lr_VAGR = 163.1). By contrast, in Egypt, food imports reduce self-sufficiency in the short run (FIG = –22.4), while no significant long-run determinants emerge, highlighting the persistent vulnerability of its food system. In Saudi Arabia, lagged income per capita negatively affects food self-sufficiency (L. GDPPC = –100.1), whereas food imports provide short-term relief (L.FIG = 87.2). However, the absence of long-run effects suggests that structural dependence on oil revenues continues to constrain sustainable improvements in food security.

The case of Qatar illustrates a different pattern, where population pressure (POP = –0.1), weak agricultural performance (D. VAGR = –0.2; LD. VAGR = –1.1), and food imports (L.FIG = –0.4) all undermine food self-sufficiency in the short run. Income per capita remains the only positive contributor (L. GDPPC = 0.3), yet agriculture continues to exert a negative effect even in the long run (lr_VAGR = –1.1). For Iraq, agriculture contributes modestly in the short run (LD.VAGR = 10.0) but without long-run sustainability. In the remaining countries (Kuwait, Oman, Tunisia, and Libya), no significant determinants are identified in either the short or long run, reflecting a structural reliance on food imports and resource rents rather than domestic agricultural capacity.

Overall, the results demonstrate that agriculture is the most consistent and sustainable determinant of food security in countries such as Morocco (lr_VAGR = 163.1), Algeria (lr_VAGR = 48.2), and Jordan (lr_VAGR = 48.2). By contrast, food imports systematically undermine self-sufficiency in the long run (e.g., Jordan –0.9, Algeria –61.2, Egypt –22.4, Qatar –0.4), reinforcing

the structural vulnerability of food systems dependent on global markets. Population growth and unbalanced economic expansion further exacerbate these challenges, particularly in rentier economies, where food security remains highly exposed to external shocks. These findings highlight the urgent need for more effective agricultural and investment policies to reduce import dependency and build sustainable food security across the region.

CONCLUSION

The findings of this study provide robust empirical evidence that agriculture remains the cornerstone of food security in the Arab world. The CS-ARDL estimations demonstrate that while rising incomes and food imports tend to weaken food self-sufficiency in the short run, agricultural production consistently enhances resilience and strengthens long-term sustainability. Although import dependence may sometimes help bridge short-term supply gaps, it undermines structural self-reliance when sustained over time, leaving economies increasingly vulnerable to external shocks and volatile international markets.

The negative short-run effect of per capita income on self-sufficiency reflects a structural imbalance between consumption and production: as household incomes rise, demand shifts toward more diverse and higher-value food products (meat, dairy, processed goods) that domestic agriculture cannot supply at the required scale or quality. This pattern is particularly evident in the case of Saudi Arabia, where results show that higher income per capita negatively affects food self-sufficiency. This outcome reflects the increased reliance on relatively cheap food imports, illustrating the "Dutch disease" effect typically associated with resource-dependent economies.

Country-level results further confirm the heterogeneity of food security determinants across the Arab world: agrarian economies such as Morocco, Algeria, and Jordan achieve sustainable gains through agricultural expansion, while resource-dependent economies such as Qatar, Kuwait, and Saudi Arabia remain constrained by structural reliance on imports and demographic pressures. These patterns emphasize that food security cannot be decoupled from investment in agriculture, technological modernization, and stronger regional cooperation.

In sum, this study highlights the urgent policy imperative of strengthening agricultural productivity and domestic self-reliance, not only as a short-term stabilization tool but as a long-term strategy to reduce vulnerability, enhance resilience, and ensure sustainable food security across the Arab world.

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Article history:	Received: 20.9.2025.
	Revised: 4.2.2026.
	Accepted: 10.2.2026.