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Cereal self-sufficiency in Arab Countries: Evidence from a dynamic difference GMM approach within a food systems framework

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Abstract---Food security remains a major challenge in Arab countries due to high cereal import dependence, demographic pressures, and exposure to external shocks. This study examines the determinants of cereal self-sufficiency in 17 Arab countries over the period 2010–2024 using a Difference GMM approach within a Food Systems Framework. The results reveal significant persistence in cereal self-sufficiency, indicating that past performance strongly influences current outcomes. Rural population share exerts a positive and statistically significant effect, whereas political stability is negatively associated with cereal self-sufficiency, reflecting contrasting food-security strategies across Arab economies. By contrast, population growth, water stress, GDP per capita growth, food price inflation, and cereal yields do not exhibit statistically significant effects. The findings suggest that cereal self-sufficiency is driven primarily by demographic and institutional factors rather than conventional production and macroeconomic variables. The study highlights the need for integrated policies combining rural development, effective governance, and long-term food-system resilience.

Keywords: Food Security, Cereal Self-Sufficiency, Arab Countries, Difference GMM, Food Systems.

JEL Classification: Q18; Q15; C23; O13; Q54.

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1. Introduction

Food security remains one of the most critical development challenges facing developing countries due to the combined effects of demographic pressures, resource constraints, market volatility, institutional weaknesses, and environmental degradation (Sen, 1981; Khouri et al., 2011). The challenge is particularly acute in the Arab region, where countries import more than half of their cereal requirements, rendering them highly vulnerable to disruptions in international food markets (FAO et al., 2023).

Despite this widespread import dependence, substantial heterogeneity characterizes cereal supply patterns across Arab countries. The average cereal import dependency ratio for the Arab region reached approximately 60%, exceeding 90% in all Gulf Cooperation Council (GCC) countries as well as in Djibouti, Jordan, and Libya. These countries therefore relied almost entirely on international markets to satisfy domestic cereal demand (FAO et al., 2023). In contrast, several middle-income economies, including Algeria, Egypt, Morocco, and Tunisia, produced between 30% and 50% of their cereal requirements domestically, while countries such as Sudan maintained comparatively larger agricultural sectors. Egypt, despite being one of the world's largest wheat importers, still produced nearly half of its domestic cereal needs (FAO et al., 2023). These disparities highlight the coexistence of distinct food-security models within the Arab region and underscore the importance of adopting a comparative perspective when analysing cereal self-sufficiency. Regional assessments also indicate persistent challenges related to food affordability and access to healthy diets across several Arab countries, reflecting broader structural vulnerabilities in regional food systems (FAO et al., 2022a). Given that nearly half of the sample consists of Mediterranean Arab countries, cereal self-sufficiency in the region is also closely linked to Mediterranean agri-food supply chains and trade relations with Southern European economies. Consequently, disruptions in regional and global grain markets have important implications for food-system resilience across both shores of the Mediterranean. These vulnerabilities are further intensified by rapid population growth, severe water scarcity, high dependence on food imports, and increasing exposure to geopolitical and economic shocks, raising concerns about the long-term sustainability and resilience of regional food systems (Godfray et al., 2010; HLPE, 2017).

Despite their strategic importance, cereal self-sufficiency levels remain constrained by several structural challenges. Environmental pressures constitute a major obstacle to agricultural development in the region. Arab countries are among the most water-scarce areas in the world, and increasing climate variability is expected to intensify pressure on agricultural production systems in the coming decades (FAO et al., 2022b; IPCC, 2022). At the same time, institutional constraints continue to limit the effectiveness of agricultural policies in several countries. Differences in governance quality, policy implementation capacity, and resource allocation mechanisms contribute to substantial disparities in agricultural performance and food security outcomes across the region (Kaufmann et al., 2011). These challenges are further compounded by demographic pressures, as population growth continues to increase demand for food and agricultural resources (Godfray et al., 2010).

The empirical analysis focuses on the period 2010–2024 because it encompasses a series of major political, economic, and food-market shocks that have profoundly affected Arab food systems. These include the post-2011 political transitions associated with the Arab uprisings, episodes of macroeconomic instability and currency crises in several countries, the COVID-19 pandemic, and the Russia–Ukraine conflict. Examining this period therefore allows for the assessment of cereal selfsufficiency under diverse and rapidly changing economic and geopolitical conditions.

The fragility associated with import dependence became particularly evident during recent global disruptions. The COVID-19 pandemic exposed weaknesses in international supply chains, whereas the Russia–Ukraine conflict disrupted global grain markets and revealed structural weaknesses in food-import-dependent economies across the Arab region (Ben Hassen & El Bilali, 2022a; El Bilali & Ben Hassen, 2024). Given that many Arab countries depend heavily on cereal imports from a limited number of exporting countries, increases in international prices and disruptions in grain exports created substantial pressures on food-importing economies (Rauschendorfer & Krivonos, 2022). These events highlighted the strategic importance of strengthening resilience of food systems and renewed interest in the determinants of cereal self-sufficiency as a key component of long-term food security policy.

From a theoretical perspective, contemporary food systems research emphasizes that food security outcomes are shaped by the interaction of demographic, institutional, economic, and environmental factors rather than by agricultural production alone (Ericksen, 2008; Ingram, 2011; HLPE, 2017). Nevertheless, empirical evidence concerning cereal self-sufficiency in Arab countries remains limited. Existing studies have primarily focused on food security indicators, agricultural productivity, or individual country experiences, while limited attention has been devoted to the determinants of cereal self-sufficiency from a regional and comparative perspective. Moreover, many studies emphasize economic and production-related variables while overlooking the potential role of institutional factors such as political stability and governance quality. Finally, relatively few studies employ dynamic panel techniques capable of accounting for persistence effects and endogeneity among food-security-related variables.

This study seeks to address these gaps by investigating the determinants of cereal self-sufficiency in a panel of seventeen Arab countries over the period 2010–2024. Drawing upon the Food Systems Framework, the analysis examines the influence of structural and institutional determinants on cereal self-sufficiency outcomes. To account for dynamic adjustment processes and potential endogeneity, the study employs the Difference Generalized Method of Moments (Difference GMM) estimator developed by Arellano and Bond (1991). The study makes three main contributions. First, it analyses cereal self-sufficiency in a diverse sample of Arab countries from a dynamic and comparative perspective grounded in the Food Systems Framework.

Second, it applies a Difference GMM framework that accounts for persistence effects and potential endogeneity. Third, it identifies a political stability paradox whereby political stability does not necessarily translate into higher cereal self-sufficiency because several stable rentier economies rely primarily on import-based food security strategies.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature and develops the research hypotheses. Section 3 presents the data, variables, and econometric methodology. Section 4 reports and discusses the empirical findings. Section 5 summarizes the main conclusions. Section 6 outlines the principal policy implications derived from the empirical results. Finally, Section 7 discusses the study's limitations and suggests directions for future research.

2. Literature Review

2.1 Theoretical Framework

The concept of food security has evolved considerably over time. Early approaches focused primarily on food availability at the national level, emphasizing aggregate production and supply. However, subsequent contributions, particularly those of Sen (1981), demonstrated that food insecurity may persist even when sufficient food is available, thereby shifting attention toward issues of access, entitlement, and distribution. This evolution led to the emergence of multidimensional frameworks in which food security is understood through four interrelated dimensions: availability, access, utilization, and stability (FAO, 2008).

More recently, the Food Systems Framework has expanded the analytical scope of food security research. Rather than treating agricultural production as an isolated activity, this perspective considers food security as the outcome of interactions among environmental resources, production systems, institutions, markets, infrastructure, and socio-economic conditions (Ericksen, 2008; Ingram, 2011). Food systems are therefore influenced not only by natural resource endowments but also by demographic dynamics, governance quality, technological development, and economic performance (HLPE, 2017).

Building on this multidimensional perspective, previous studies argue that food security outcomes cannot be explained solely by agricultural production levels but are shaped by the interaction of economic, demographic, environmental, and institutional factors operating within broader food systems (Khouri et al., 2011).

Within this framework, cereal self-sufficiency represents an important indicator of the availability dimension of food security. It reflects the capacity of domestic cereal production to satisfy national consumption requirements and reduce dependence on external markets. Although complete self-sufficiency is not necessarily the most efficient outcome under international trade (FAO, 2015), maintaining an adequate level of domestic cereal production contributes to resilience of food systems and reduces vulnerability to external shocks, supply disruptions, and price volatility (FAO et al., 2022a).

2.2 Empirical Literature

Empirical studies identify several categories of determinants influencing food security and agricultural performance.

A first group of studies emphasizes demographic factors. Rapid population growth increases food demand and may exert pressure on domestic production systems when agricultural output fails to expand at a comparable pace (Godfray et al., 2010). In contrast, the rural population may contribute positively to agricultural production by providing labor resources and sustaining farming activities, particularly in developing economies where agriculture remains labour-intensive.

A second strand of literature highlights environmental constraints. Water scarcity is widely recognized as one of the principal limitations to agricultural development in arid and semi-arid regions. Declining water availability reduces crop productivity, limits cultivated areas, and constrains long-term food production capacity (FAO et al., 2022b; IPCC, 2022). These challenges are especially pronounced in Arab countries, which possess some of the lowest per capita renewable water resources globally.

Economic determinants constitute a third category of explanatory factors. Economic growth can improve food security through higher investment capacity, technological adoption, and infrastructure development. Nevertheless, in import-dependent economies, increasing income levels may strengthen reliance on international markets rather than stimulate domestic agricultural production. Similarly, food price inflation may influence both production incentives and consumption patterns, generating heterogeneous effects across countries (ESCWA, 2022a).

More recent research has increasingly emphasized the importance of institutional factors. Governance quality, political stability, and policy effectiveness shape agricultural investment decisions, resource allocation, and the implementation of food security strategies (Kaufmann et al., 2011). However, evidence from several resource-rich economies suggests that political stability does not necessarily translate into greater domestic agricultural production, particularly when food security is achieved through import-financed strategies rather than local production expansion (Harrigan, 2014; Eibl et al., 2022).

Existing empirical evidence on cereal self-sufficiency remains fragmented. Most studies focus on individual countries, specific agricultural sectors, or selected dimensions of food security. Regional reports provide valuable descriptive assessments of food-system vulnerabilities, climate risks, and import dependence (ESCWA, 2022b), yet comparatively few studies have employed a unified econometric framework to investigate the determinants of cereal self-sufficiency across Arab countries characterized by substantial economic, institutional, and environmental heterogeneity.

2.3 Research Gap and Hypotheses Development

Despite the growing body of literature on food security and agricultural development, several limitations remain.

First, existing studies predominantly focus on individual countries or specific subregions, limiting the identification of common structural determinants across Arab economies. Second, empirical analyses frequently emphasize agricultural and environmental variables while giving comparatively less attention to institutional factors. Third, relatively few studies employ dynamic panel techniques capable of accounting for persistence effects and endogeneity, despite the inherently dynamic nature of food security outcomes.

Moreover, the coexistence of highly import-dependent rentier economies alongside more agriculture-oriented economies within the Arab region raises important questions regarding the relative contribution of demographic, institutional, economic, and environmental factors to cereal self-sufficiency. This heterogeneity remains insufficiently explored in the existing literature.

To address these gaps, the present study develops the following hypotheses:

H1: A larger rural population positively influences cereal self-sufficiency by supporting agricultural labor availability and domestic production capacity.

H2: Political stability is expected to influence cereal self-sufficiency, although the direction of the relationship remains theoretically ambiguous in the Arab context.

H3: Population growth negatively affects cereal self-sufficiency by increasing food demand relative to domestic production capacity.

H4: Water stress negatively affects cereal self-sufficiency by constraining agricultural productivity and resource availability.

H5: Economic growth influences cereal self-sufficiency, although the direction of the relationship may vary according to economic structure and the degree of import dependence.

H6: Food price inflation significantly influences cereal self-sufficiency through its effects on production incentives, consumer demand, and domestic food-market conditions.

H7: Higher cereal yields positively contribute to cereal self-sufficiency by improving agricultural productivity and domestic food availability.

Building upon these hypotheses, the study employs a dynamic Difference GMM approach to evaluate the relative importance of demographic, institutional, economic, and environmental determinants of cereal self-sufficiency across Arab countries during the period 2010–2024.

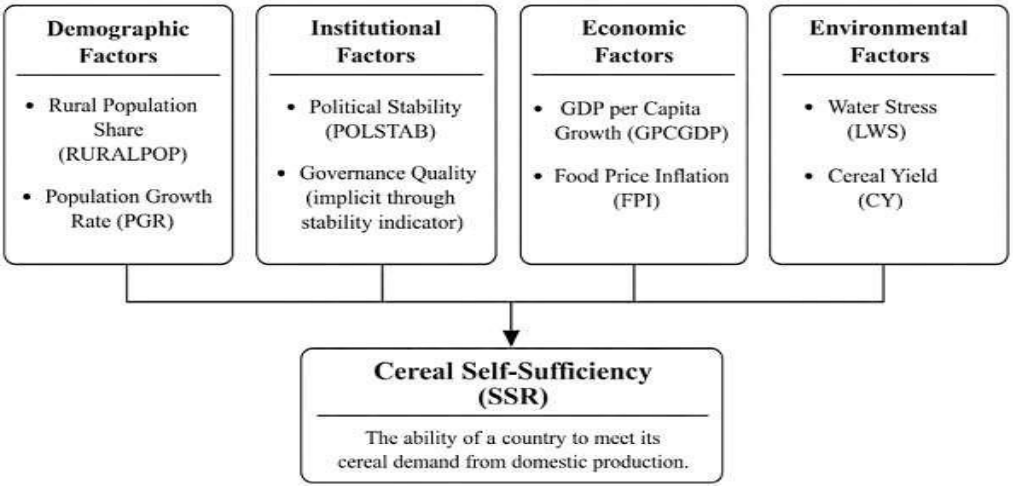

Figure 1. Conceptual Framework: Determinants of Cereal Self-Sufficiency in Arab Countries
Source: Authors' elaboration based on Ericksen (2008), Ingram (2011), and HLPE (2017).

3. Data and Methodology

3.1 Sample and Data Sources

This study investigates the determinants of cereal self-sufficiency in a panel of 17 Arab countries over the period 2010–2024. The sample was selected to ensure broad geographical and economic representation of the Arab region, encompassing countries from North Africa, the Gulf Cooperation Council (GCC), the Mashreq, the Nile Basin, and the Horn of Africa. The selected countries exhibit substantial heterogeneity in terms of economic structure, agricultural capacity, institutional quality, demographic characteristics, and natural resource endowments, thereby providing an appropriate empirical setting for examining the determinants of cereal self-sufficiency across diverse food systems.

Table 1 presents the classification of sample countries according to their degree of cereal import dependency. The classification is based on the average cereal import dependency ratio derived from FAOSTAT data for the period 2010–2024. Distinguishing countries according to their level of import dependence allows for a better understanding of the structural diversity characterizing Arab food systems and provides additional context for interpreting cross-country differences in cereal self-sufficiency outcomes.

Table 1
Classification of Arab Countries According to Cereal Import Dependency

Category	Countries	endency Rate	Key Determinants
High Dependency (>90%)	UAE, Kuwait, Qatar, Saudi Arabia, and Djibouti	91–98.7%	Rentier economies, severe water scarcity, and limited domestic agricultural production
Medium Dependency (60–90%)	Algeria, Tunisia, Iraq, Lebanon, Libya, Jordan, and Oman	63–83%	Water scarcity, infrastructure constraints, and political instability
Low Dependency (<60%)	Morocco, Egypt, Sudan, Syria, and Mauritania	49.8–58%	Larger agricultural sectors, greater land availability, and stronger domestic production capacity

Source: Authors' compilation based on FAO data.

The empirical analysis is based on a balanced panel dataset covering 17 Arab countries over the period 2010–2024. Data were compiled from internationally recognized sources to ensure consistency and cross-country comparability. Information on cereal production, imports, and exports was obtained from FAOSTAT, while demographic, macroeconomic, food price inflation, and water-stress indicators were drawn from the World Development Indicators (WDI). Institutional variables were sourced from the Worldwide Governance Indicators (WGI) database. The study period spans several major events that shaped regional food systems, including the post-2011 political transitions, the COVID-19 pandemic, and the Russia–Ukraine conflict.

3.2 Variables and Measurement

The dependent variable is the Cereal Self-Sufficiency Ratio (SSR), which measures the extent to which domestic cereal production satisfies national consumption requirements. Following FAO methodology (FAO, 2015), the cereal self-sufficiency ratio is calculated as follows:

$$Self - Sufficiency\ Ratio(SSR) = \frac{Domestic\ Production}{(Domestic\ Production + Imports - Exports)} \times 100\%$$

Higher values indicate greater reliance on domestic cereal production and lower dependence on external food supplies. To explain variations in cereal self-sufficiency, the study incorporates demographic, institutional, economic, and environmental variables derived from the Food Systems Framework. Table 2 summarizes the variables employed in the analysis.

Table 2. Definition of Explanatory Variables and Data Sources

Variable	Definition	Unit	Source
CY	Cereal yield, measured as cereal production per cultivated hectare, reflecting agricultural productivity	kg/ha	FAO (FAOSTAT)
FPI	Food Price Inflation Rate, measured as the annual percentage change in domestic food prices	%	World Development Indicators (WDI)
RURALPOP	Rural population as a share of total population, reflecting agricultural labour availability and rural production capacity	% of total population	World Bank (WDI)
PGR	Annual population growth rate, capturing demographic pressure on food demand	% per year	World Bank (WDI)
LWS	Level of water stress, measured as freshwater withdrawals as a percentage of total available renewable freshwater resources	%	World Bank (WDI)
GPCGDP	Annual GDP per capita growth rate at constant prices, reflecting overall economic performance	% per year	World Bank (WDI)
POLSTAB	Political Stability and Absence of Violence Index, capturing institutional and political conditions	Index (−2.5 to +2.5)	World Bank (WGI)

Source: Authors' compilation based on FAO, World Development Indicators (WDI), and Worldwide Governance Indicators (WGI).

3.3 Econometric Model Specification

Given the dynamic nature of food systems and the persistence of agricultural production patterns, cereal self-sufficiency is expected to depend partly on its past values. To capture this dynamic behavior, the following model is specified:

$$\boldsymbol{SSR_{it} = \alpha SSR_{it-1} + \beta_1 RURALPOP_{it} + \beta_2 POLSTAB_{it} + \beta_3 PGR_{it} + \beta_4 LWS_{it} + \beta 5 GPCGDPit + \beta 6 FPIit + \beta 7 CYit + \mu i + \varepsilon it}$$

where:

- SSR_{it}denotes the cereal self-sufficiency ratio in country (i) at time (t);
- SSR_{it-1} represents the one-period lagged value of the cereal self-sufficiency ratio and captures persistence effects and path dependency;
- α denotes the autoregressive coefficient measuring the degree of persistence in cereal selfsufficiency over time;
- $\boldsymbol{\beta_1}$ **-** $\boldsymbol{\beta_7}$ are the coefficients associated with the explanatory variables;
- $\boldsymbol{\mu_i}$ represents unobserved country-specific effects;
- $\boldsymbol{\varepsilon_i}$ **is** the idiosyncratic error term.

The inclusion of the lagged dependent variable allows the model to capture the dynamic adjustment process of food systems and the persistence of agricultural production structures across countries.

3.4 Estimation Strategy and Diagnostic Tests

Estimating the dynamic model using conventional fixed-effects or random-effects estimators may produce biased and inconsistent estimates because of the inclusion of the lagged dependent variable, unobserved country-specific heterogeneity, and potential endogeneity. To address these issues, this study employs the Difference Generalized Method of Moments (Difference GMM) estimator developed by Arellano and Bond (1991).

The Difference GMM estimator removes country-specific effects through first differencing while exploiting lagged values as internal instruments. This approach is particularly suitable for dynamic panel models characterized by persistence and potential simultaneity between cereal self-sufficiency and its determinants.

The estimation is based on first-differenced equations using a White period weighting matrix and heteroskedasticity-consistent standard errors clustered at the cross-sectional level. Owing to differencing and lag construction, the effective sample decreases from 255 to 221 country-year observations.

In the baseline specification, the lagged dependent variable, SSR, is treated as endogenous and instrumented using its second lag in levels, SSR(-2). The remaining explanatory variables are treated as predetermined and are instrumented using their first lagged values, namely RURALPOP(-1), POLSTAB(-1), PGR(-1), LWS(-1), GPCGDP(-1), FPI(-1), and CY(-1). To avoid instrument proliferation and overfitting in this relatively small panel (N = 17), the instrument matrix was deliberately restricted to 17 instruments, following Roodman (2009). Difference GMM was preferred over System GMM because of its greater parsimony in small samples.

Model validity is assessed using the Sargan test of overidentifying restrictions and the Arellano–Bond serial correlation test. In particular, failure to reject the null hypothesis of no second-order serial correlation [AR(2)] is interpreted as supporting the consistency of the Difference GMM estimator.

4. Empirical Results

4.1 Descriptive Statistics and Correlation Analysis

4.1.1 Descriptive Statistics

Table 3 presents the descriptive statistics for the variables included in the analysis. The results reveal substantial cross-country heterogeneity, reflecting marked differences in demographic structures, institutional conditions, economic performance, and agricultural systems across Arab countries.

Table 3. Descriptive Statistics of Study Variables

Statistic	SSR	RURALPOP	POLSTAB	PGR	LWS	GPCGDP	FPI	CY
Mean	0.312684	26.71034	-0.803074	2.307840	493.4549	-0.308465	5.715678	5013.669
Median	0.108619	22.58300	-0.630951	2.019531	118.6564	0.118554	0.640004	2007.600
Maximum	2.000000	66.91100	1.223599	14.22540	385.5000	91.78137	237.6730	36761.90
Minimum	0.000000	0.000000	-3.093678	-10.92744	6.333333	-49.12786	-266.6420	451.7000
Std. Dev.	0.378374	18.43805	1.086792	2.631304	881.8022	9.045048	28.90018	6470.905
Skewness	1.701831	0.514079	-0.185296	0.240588	2.633960	3.329702	0.291207	2.419221
Kurtosis	6.679493	2.383300	2.120268	8.369044	9.441280	48.27992	56.47932	9.325284
Jarque-Bera	266.9381	15.27267	9.682203	308.7430	735.6865	22255.33	30391.51	673.8347
Probability	0.000000	0.000000	0.007898	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	79.73454	6811.136	-204.7838	588.4992	125831.0	-78.65864	1457.498	1278486
Sum Sq. Dev.	36.36436	86350.24	300.0038	1758.635	1.98E+08	20780.48	212146.0	1.06E+10
Observations	255	255	255	255	255	255	255	255

Source: Researchers' compilation based on Eviews 12 results

The average cereal self-sufficiency ratio (SSR) is 31.3%, indicating that domestic cereal production satisfies less than one-third of total cereal requirements on average. The substantial gap between the mean (0.313) and median (0.109), together with the positive skewness coefficient (1.70), reveals a highly asymmetric distribution in which only a few countries achieve relatively high levels of cereal self-sufficiency, while most remain highly dependent on cereal imports. The maximum value of 2.00 indicates that some observations experienced temporary cereal surpluses.

Considerable heterogeneity is also observed across the explanatory variables. Rural population share (RURALPOP) ranges from 0% to approximately 67%, reflecting the coexistence of highly urbanized Gulf economies and predominantly agrarian countries such as Sudan and Mauritania. Political stability (POLSTAB) varies from −3.09 to 1.22, highlighting substantial institutional diversity across the region. Environmental and economic indicators exhibit particularly high variability. The Level of Water Stress (LWS) ranges from 6.3% to 385.50%, with values exceeding 100% reflecting freshwater withdrawals above renewable resources. In several Gulf countries, these extreme values are associated with severe water scarcity and reliance on desalination and non-renewable groundwater resources (Allen, 2011; FAO et al., 2022b). Food price inflation (FPI) also displays substantial dispersion, reflecting heterogeneous inflationary experiences, especially in countries affected by macroeconomic instability such as Lebanon and Sudan (ESCWA, 2022a; Rauschendorfer & Krivonos, 2022).

Similar variability characterizes cereal yields (CY) and GDP per capita growth (GPCGDP), indicating marked disparities in agricultural productivity and macroeconomic performance across Arab countries. Most variables depart from normality, as evidenced by high skewness and kurtosis values and statistically significant Jarque–Bera statistics. These findings further justify the use of the Difference GMM estimator, which is robust to heterogeneity and potential endogeneity (Arellano & Bond, 1991; Roodman, 2009).

4.1.2 Correlation Analysis

Table 4 presents the pairwise correlation matrix among the study variables. The results provide preliminary evidence regarding the associations between cereal self-sufficiency and its potential determinants.

Table 4. Correlation Analysis between Variables

Variable	SSR	RURALPOP	POLSTAB	PGR	LWS	GPCGDP	FPI	CY
SSR	1							
RURALPOP	0.654569	1						
POLSTAB	-0.346407	-0.573184	1					
PGR	-0.190599	-0.137864	0.249860	1				
LWS	-0.348619	-0.484518	0.347210	0.168087	1			
GPCGDP	-0.013222	-0.020873	0.092314	-0.133583	-0.040817	1		
FPI	0.064587	0.142085	-0.185459	-0.164056	-0.071349	-0.133890	1	
CY	-0.344730	-0.374625	0.566643	0.196422	0.527079	0.009803	-0.085450	1

Source: Researchers' compilation based on Eviews 12 results

The strongest positive association is observed between cereal self-sufficiency (SSR) and rural population share (RURALPOP) ($r = 0.655$), indicating that countries with larger rural populations tend to exhibit higher levels of cereal self-sufficiency. This pattern is broadly consistent with the importance of rural areas for agricultural production in several Arab countries.

In contrast, political stability (POLSTAB) exhibits a moderate negative correlation with cereal self-sufficiency ($r = -0.346$). Although correlation analysis does not imply causality, this result suggests that differences in food-system structures and development patterns may exist across the sample countries. The nature of this relationship is examined more rigorously in the dynamic econometric analysis.

Water stress (LWS) is also negatively associated with cereal self-sufficiency ($r = -0.349$), suggesting that greater pressure on water resources may be associated with lower levels of domestic cereal self-sufficiency. Similarly, cereal yield (CY) displays a moderate negative correlation with SSR ($r = -0.345$). Given the substantial heterogeneity of the sample, this relationship should be interpreted with caution and may reflect structural differences among countries.

The remaining explanatory variables show relatively weak associations with cereal self-sufficiency. Population growth (PGR) exhibits a weak negative correlation ($r = -0.191$), while GDP per capita growth (GPCGDP) and Food Price Inflation Rate (FPI) display very limited correlations with SSR ($r = -0.013$ and $r = 0.065$, respectively). These findings suggest the absence of strong linear associations between these variables and cereal self-sufficiency at the bivariate level.

Overall, the correlation coefficients remain moderate in magnitude. The highest absolute correlation among the explanatory variables is observed between RURALPOP and POLSTAB ($r = -0.573$), followed by POLSTAB and CY ($r = 0.567$). Since none of the pairwise correlations exceed the conventional threshold of 0.80, multicollinearity does not appear to constitute a serious concern. Consequently, all explanatory variables were retained in the baseline econometric specification without further modification.

4.2 Baseline Results

Table 5 reports the baseline Difference GMM estimation results for the determinants of cereal self-sufficiency. The specification incorporates the lagged dependent variable to account for persistence effects and potential path dependency in food-system performance.

Table 5. Model Estimation Results Using GMM First Difference

Variable	Coefficient	t-Statistic	Prob
SSR(-1)	0.373229	62.82505	0.0000
RURALPOP	0.007536	3.027286	0.0080
POLSTAB	-0.128575	-3.631299	0.0022
PGR	0.005362	0.262974	0.7959
LWS	-0.000247	-0.575234	0.5731
GPCGDP	-0.0000165	-0.110606	0.9133
FPI	0.000000796	0.146858	0.8851
CY	0.00000958	1.339700	0.1991
Number of Obs	221		
Number of groups	17		
J-statistic	11.17326		
Prob(J-statistic)	0.264020		

Source: Researchers' compilation based on Eviews 12 results

The estimated autoregressive coefficient associated with the lagged self-sufficiency ratio, SSR(-1), is positive and highly significant ($\alpha = 0.373$, $p < 0.01$), indicating substantial persistence in cereal self-sufficiency levels over time. This finding suggests that past levels of cereal self-sufficiency continue to influence current outcomes, reflecting the long-term nature of agricultural production systems and food policy decisions.

Among the explanatory variables, only rural population and political stability exhibit statistically significant effects. Rural population (RURALPOP) has a positive and significant coefficient ($\beta = 0.0075$, $p < 0.01$), indicating that countries with larger rural populations tend to achieve higher levels of cereal self-sufficiency. In contrast, political stability (POLSTAB) displays a negative and statistically significant coefficient ($\beta = -0.129$, $p < 0.01$), suggesting an inverse relationship between political stability and cereal self-sufficiency within the sample.

The remaining explanatory variables, namely population growth (PGR), water stress (LWS), GDP per capita growth (GPCGDP), Food Price Inflation Rate (FPI), and cereal yield (CY), do not achieve conventional levels of statistical significance. Their coefficients remain relatively small and do not provide evidence of a systematic influence on cereal self-sufficiency during the study period. Overall, the baseline results indicate that demographic and institutional factors appear to play a more prominent role than conventional economic and agricultural variables in explaining variations in cereal self-sufficiency across Arab countries.

4.3 Results Discussion

4.3.1 Persistence and Path Dependence

The highly significant coefficient of the lagged dependent variable (SSR(-1)) indicates strong persistence in cereal self-sufficiency across Arab countries. The estimated coefficient (0.373) suggests that about one-third of past performance carries over to subsequent periods. This reflects the cumulative nature of agricultural systems, where investments in irrigation, storage, technology, and institutions create long-lasting effects.

This finding is consistent with the Food Systems Framework, which explains food security outcomes as the result of long-term interactions among environmental, economic, and institutional factors rather than short-term market fluctuations (Ericksen, 2008; Ingram, 2011; HLPE, 2017). It also aligns with studies highlighting persistence and path dependence in agricultural and food security outcomes in developing countries (Rosegrant et al., 2014; El Bilali & Ben Hassen, 2020).

4.3.2 Rural Population and Agricultural Capacity

The positive and statistically significant coefficient associated with rural population confirms that demographic structure remains a key determinant of cereal self-sufficiency in Arab countries. Larger rural populations support agricultural labour supply, sustain farming activities, and preserve production knowledge, thereby strengthening domestic cereal output. Therefore, H1 is supported. This finding is consistent with studies emphasizing the role of rural economies in sustaining agricultural production and food availability in developing regions (Godfray et al., 2010; FAO et al., 2022a). It also corroborates Khouri et al. (2011), who stressed the importance of agricultural labour and rural livelihoods for food security in Arab countries. However, it differs from evidence in highly industrialized economies, where mechanization has reduced dependence on rural population size. This discrepancy may reflect the continued importance of labour-intensive agriculture in many Arab countries.

4.3.3 The Political Stability Paradox

One of the most notable findings of this study is the negative and statistically significant relationship between political stability and cereal self-sufficiency. Although this appears to contradict the conventional view that political stability improves governance and policy effectiveness (Kaufmann et al., 2011), the Arab context offers a plausible explanation.

The finding contrasts with literature suggesting that political stability supports agricultural performance and food security through stronger institutions and better policy implementation (Kaufmann et al., 2011; FAO et al., 2022a). However, it is consistent with studies on the political economy of food security in the Arab region, which show that several high-income rentier economies rely mainly on import-based strategies rather than domestic production (Harrigan, 2014; Eibl et al., 2022).

Several of the most politically stable countries in the sample are high-income Gulf economies facing severe land and water constraints. Rather than expanding domestic cereal production, they secure food supplies through imports, strategic reserves, and integration into global food markets (Eibl et al., 2022). Thus, political stability improves access to food without necessarily increasing cereal self-sufficiency. This interpretation is supported by studies on GCC countries, which show that food security strategies increasingly rely on import diversification, strategic reserves, and overseas investments rather than domestic cereal production alone (Ben Hassen & El Bilali, 2019).

The rejection of H2 therefore highlights the heterogeneity of food security strategies across Arab countries. The negative coefficient reflects structural differences between import-based and production-based models rather than a simple adverse effect of political stability on agricultural performance.

Importantly, this finding should not be interpreted as evidence that political instability improves performance of food systems. Rather, it suggests that politically stable rentier economies may achieve food security through imports while remaining weak in cereal self-sufficiency. This underscores the need to distinguish between food security and cereal self-sufficiency, which do not always move in the same direction.

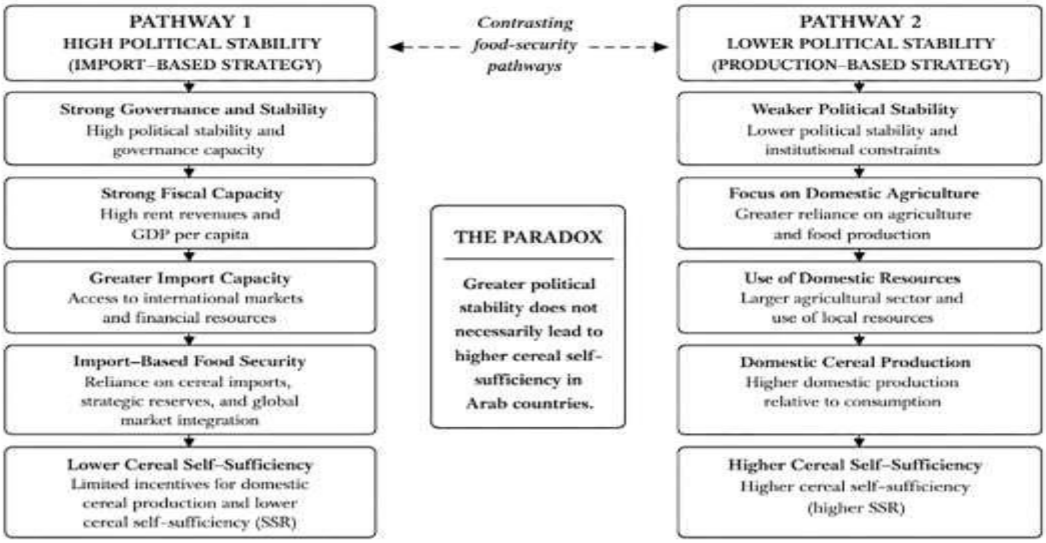

Figure 2. Mechanism of the Political Stability–Self-Sufficiency Paradox in Arab Countries
Source: Authors' elaboration based on the empirical findings and the Food Systems Framework (Ericksen, 2008; Ingram, 2011; HLPE, 2017).

4.3.4 Non-Significant Determinants of Cereal Self-Sufficiency

Several variables commonly linked to food security, namely population growth, water stress, GDP per capita growth, food price inflation, and cereal yields, do not show statistically significant effects in the model. This finding may reflect the structural features of Arab food systems, where cereal availability depends not only on production conditions but also on trade integration, public policy, and import strategies.

The lack of significance for these variables contrasts with conventional food-security literature, which generally identifies productivity, income growth, and natural-resource availability as major determinants of food availability (Godfray et al., 2010; Rosegrant et al., 2014). However, the results are consistent with the Food Systems perspective, which emphasizes that food security outcomes emerge from interdependent structural processes operating across entire food systems rather than from isolated production variables alone (Ericksen, 2008; Ingram, 2011).

The non-significant effect of water stress may be explained by adaptation strategies implemented across several Arab countries. Efficient irrigation technologies, improved water governance, desalination, and the use of virtual water imports may partially mitigate the adverse effects of water scarcity on domestic food systems (Allen, 2011; Ben Hassen & El Bilali, 2022b; FAO et al., 2022b). In particular, Gulf countries have increasingly relied on non-conventional water resources and integrated water-management strategies to reduce vulnerability to severe water scarcity (Ben Hassen & El Bilali, 2022b). In addition, resilient food systems are increasingly characterized by their capacity to adapt to resource constraints and external shocks through institutional and technological adjustments (Ben Hassen et al., 2025). Likewise, higher income levels may improve access to food through international markets rather than stimulate domestic cereal production. Food price inflation may also be moderated by subsidies, strategic reserves, exchange-rate interventions, and trade policies implemented in several Arab economies (Eibl et al., 2022).

Similarly, the absence of a significant effect of cereal yields suggests that productivity gains alone are insufficient to raise cereal self-sufficiency in Arab countries. Although higher yields increase output per hectare, these gains may be offset by rising demand driven by population growth, changing dietary patterns, and urbanization. Moreover, cereal self-sufficiency depends on total domestic production rather than yield alone. In several Arab countries, improvements in cereal yields have often been accompanied by reductions in cultivated or harvested areas, thereby limiting their overall contribution to total cereal production and self-sufficiency. This finding accords with previous research emphasizing that food security and self-sufficiency depend on broader structural and institutional conditions rather than solely on agricultural productivity (HLPE, 2017; El Bilali & Ben Hassen, 2024). Overall, these findings suggest that cereal self-sufficiency in Arab countries is influenced more by structural and institutional characteristics than by conventional production-related factors alone.

4.4 Robustness and Diagnostic Tests

Post-estimation diagnostic tests were conducted to assess model reliability.

4.4.1 Instrument Validity

The validity of the instruments was evaluated using the Sargan test of overidentifying restrictions. The test does not reject the null hypothesis that the instruments are jointly valid and exogenous (Jstatistic = 11.17; $p = 0.264$), indicating that the selected lagged instruments are appropriately correlated with the endogenous regressors while remaining uncorrelated with the error term. Furthermore, the instrument matrix was deliberately restricted to avoid instrument proliferation. The final specification employs 17 instruments for 17 cross-sectional units, a ratio that remains well within commonly recommended limits for dynamic panel estimation and reduces the risk of overfitting in small-N panels (Roodman, 2009). Together, these results support the validity and robustness of the chosen Difference GMM specification.

4.4.2 Serial Correlation

Serial correlation in the first-differenced residuals was examined using the Arellano–Bond test. A key requirement for the consistency of the Difference GMM estimator is the absence of second-order serial correlation in the differenced error term. The AR(2) statistic fails to reject the null hypothesis of no second-order serial correlation ($p = 0.9994$), thereby supporting the validity of the lagged instruments and the consistency of the estimated coefficients (Arellano & Bond, 1991). This result indicates that there is no evidence of remaining serial dependence at order two in the transformed residuals, which is essential for the correct specification of the dynamic panel model. Overall, the AR(2) diagnostic confirms that the model is properly specified and that the Difference GMM estimator is econometrically appropriate for the empirical analysis. The AR(1) test does not strongly reject the null in this small-N panel, which may reflect limited power; however, the absence of second-order serial correlation remains the key consistency condition for the Difference GMM estimator.

4.4.3 Robust Standard Errors

To account for potential heteroskedasticity and within-country dependence, the estimation was performed using a White period weighting matrix combined with cross-section clustered standard errors. This procedure enhances the robustness of statistical inference and improves the reliability of coefficient significance tests.

Overall, the diagnostic results support the econometric adequacy of the Difference GMM specification and reinforce the credibility of the estimated relationships between cereal self-sufficiency and its determinants in Arab countries.

5. Conclusions

This study investigated the determinants of cereal self-sufficiency in 17 Arab countries during 2010–2024 using a dynamic Difference GMM framework grounded in the Food Systems Framework. The results reveal a significant persistence effect, indicating that current self-sufficiency levels are strongly influenced by past production structures, institutional arrangements, and policy choices. This finding highlights the long-term and path-dependent nature of cereal production systems and food policies.

Among the explanatory variables, rural population share emerges as the only positive and statistically significant determinant of cereal self-sufficiency. This result underscores the continued importance of rural economies, agricultural labour availability, and domestic production capacity in strengthening resilience of food systems across the region.

A central finding of the study is the negative and significant relationship between political stability and cereal self-sufficiency. Rather than implying that political stability undermines food security, this result reflects the coexistence of two distinct food-security models in the Arab world. Several politically stable rentier economies rely primarily on imports, strategic reserves, and international market integration to secure food supplies, whereas more agriculture-oriented economies depend relatively more on domestic cereal production. This "political stability paradox" highlights the need to distinguish between food security and cereal self-sufficiency. In contrast, population growth, water stress, GDP per capita growth, food price inflation, and cereal yields do not exhibit statistically significant effects.

Overall, the study extends the application of the Food Systems Framework to Arab countries and demonstrates that structural and institutional factors constitute the primary determinants of cereal self-sufficiency in the Arab context. Strengthening resilience therefore requires integrated policies that combine rural development, effective governance, and long-term food-system planning alongside agricultural production objectives.

6. Policy Implications

The empirical findings indicate that strengthening cereal self-sufficiency in Arab countries requires a food-systems perspective that extends beyond conventional production-oriented policies.
First, rural development should be prioritized through investments in rural infrastructure, support for agricultural labour, and measures aimed at improving the resilience and productivity of domestic cereal production systems.
Second, given the region's severe resource constraints, policies promoting water-use efficiency should be reinforced through modern irrigation technologies, water-saving agricultural practices, and sustainable water-resource management.
Third, food security strategies should be adapted to country-specific structural conditions. While GCC countries may continue to rely on import-based food-security models supported by financial capacity and strategic grain reserves, countries with greater agricultural potential should prioritize sustainable expansion of domestic cereal production.
Fourth, enhanced regional cooperation in agricultural trade, knowledge transfer, and food-security initiatives could strengthen the resilience of Arab food systems and reduce vulnerability to external shocks.
Finally, increasing climate variability necessitates the integration of climate adaptation measures into food security strategies, including climate-smart agriculture, drought-resistant crop varieties, and improved risk-management mechanisms.

7. Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. First, although the sample includes countries with diverse economic and agricultural structures, important differences remain between GCC and non-GCC economies in terms of resource endowments, agricultural capacity, and food import dependence. Future research could explore this heterogeneity through sub-sample analyses or alternative modelling strategies.

Second, a limited number of countries, particularly conflict-affected economies, were excluded because of persistent data gaps and the lack of consistent observations for key variables. These data constraints also prevented the inclusion of additional determinants related to climate conditions, technological adoption, agricultural innovation, and other food-system dimensions. Future studies could extend the analysis as more comprehensive and reliable datasets become available.

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