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EXPLORING THE LINK BETWEEN FINANCIAL INCLUSION AND FOOD SECURITY IN ALGERIA: A VECM Approach

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Abstract

This study explores the link between financial inclusion and food security in Algeria from 2003 to 2022. Using a composite financial inclusion index and the Vector Error Correction Model (VECM), we analyse the data, subjecting it to various diagnostic tests. Surprisingly, our results reveal that financial inclusion (FI) has a significant and positive impact on undernourishment prevalence, indicating a negative effect on food security in both the short and long term. Likewise, food imports (FIM) contribute to higher undernourishment prevalence, implying a weakening of food security in the long-run. Conversely, unemployment rate (UEM) and food production (FOP) show no substantial long-term impact on food security, although UEM has an opposing effect in the short run, meaning it improves food security at the short term; which can be attributed to the informal economy and other State's policies. Notably, income per capita (INCAPITA) negatively affects undernourishment prevalence, improving food security. These findings offer a nuanced understanding of the complex relationship between financial inclusion and food security in Algeria, emphasizing the need for multifaceted, context-specific policies to address the country's unique challenges.

Keywords: financial inclusion, food security, prevalence of undernourishment, Vector Error correction model (VECM), Algeria.

JEL Classification Codes: B26, C58, D53, E44, L66.

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1. Introduction

The current study focuses on two interconnected concepts: financial inclusion and food security. These concepts play a pivotal role in poverty reduction, addressing hunger, and promoting sustainable development in today's rapidly changing world. Financial inclusion encompasses the provision of affordable and relevant financial products and services to individuals and businesses, including transactions, payments, savings, credit, and insurance. It also emphasizes responsible and sustainable service delivery (World bank, 2022). Furthermore, financial inclusion strives to ensure universal access to formal financial services (Karmakar et al., 2011; Malik et al., 2022). In contrast, as defined by the Rome Declaration on World Food Security, food security signifies the consistent availability of food, guaranteeing that every individual has the means to obtain it. This food should not only be continually accessible but also meet nutritional standards in terms of quantity, quality, diversity, and cultural preferences (Clover, 2003). It is achieved when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that satisfies their dietary requirements and food preferences for an active and healthy life (FAO, 2007).

Importantly, financial inclusion holds the potential to significantly contribute to achieving food security by extending access to credit, insurance, savings, and payment services to those currently excluded from financial institutions. This can result in poverty reduction, the stimulation of entrepreneurship, and enhanced social and economic empowerment as individuals and communities become active participants in the formal economy (UNCDF, 2017; World bank, 2022).

In the context of Algeria, food security is acknowledged as a paramount challenge on the horizon for both its economy and society. the exploration of the link between financial inclusion and food security gains prominence, primarily due to the role of financial inclusion in bolstering people's resilience, as discussed by Moore et al.(2019).

Algeria, a developing nation facing distinct challenges and opportunities, is actively working to harness the potential of financial inclusion as a driver of sustainable development (Prime Minister Office, 2020), aligning with its pursuit of various Sustainable Development Goals (SDGs), including the alleviation of hunger and the assurance of food security. Algeria, being a developing nation facing unique challenges and opportunities, is actively striving to leverage the potential of financial inclusion as a catalyst for achieving sustainable progress. Algeria's strategic approach is underpinned by the preservation of the state's social character to promote greater social equity and protect the purchasing power of its citizens, especially the most vulnerable groups. Simultaneously, it endeavours to fortify the nation's food security, a pivotal component in safeguarding its national sovereignty and ensuring autonomy in economic decision-making for the benefit of the country's development.

Therefore, this research endeavours to shed light on how improving financial inclusion can lead to positive socio-economic outcomes, laying the groundwork for poverty

reduction, increased entrepreneurship, and enhanced financial resilience (Klapper et al., 2016; World Bank, 2022). The provision of appropriate financial services can foster the creation and growth of small and medium-sized enterprises (SMEs), contributing to job creation and hunger alleviation resulting in food security (UNCDF, 2017). Furthermore, financial inclusion can bolster household financial stability, enabling families to cope with unforeseen shocks and invest in education, healthcare, and housing (Moore et al., 2019).

This research aims to illuminate the relationship between improved financial inclusion and positive socio-economic outcomes, forming the foundation for poverty reduction, increased entrepreneurship, and heightened financial resilience (Klapper et al., 2016; World Bank, 2022). The provision of appropriate financial services can stimulate the establishment and growth of small and medium-sized enterprises (SMEs), thereby contributing to job creation and alleviating hunger, ultimately bolstering food security (UNCDF, 2017). Additionally, financial inclusion can fortify household financial stability, equipping families to navigate unforeseen shocks and invest in vital areas such as education, healthcare, and housing (Moore et al., 2019). This multifaceted exploration seeks to unveil the intricate dynamics between financial inclusion and food security, particularly in the context of Algeria.

The main objective of the study is to examine the impact of financial inclusion on food security in Algeria. However, the study is guided by the following sub-objectives:

1. To gain insight into the evolution of financial inclusion in Algeria;
2. To analyse the impact of financial inclusion on undernourishment in Algeria.

In the subsequent sections, we delve into the existing literature on financial inclusion and food security, discuss the key methodologies employed in this research, present the trends of financial inclusion, outline our findings, and conclude with a discussion and recommendations aimed at unlocking the full potential of financial inclusion for food security in Algeria. By investigating the dynamic relationship between financial inclusion and food security, as proxied by the undernourishment rate, this study aims to provide evidence-based insights that can guide policy formulation and promote inclusive development practices. Ultimately, our goal is to contribute to a more prosperous and resilient Algeria, with undernourishment rates approaching zero.

2. Literature Review

a. Conceptual framework

The conceptual framework, presented in Figure 2.1 below, provides a visual representation of the key constructs under examination in this study. It has been thoughtfully designed to elucidate how financial inclusion, as measured by a composite index derived through Principal Component Analysis (PCA), can impact food security outcomes. The framework elucidates the relationships between the independent

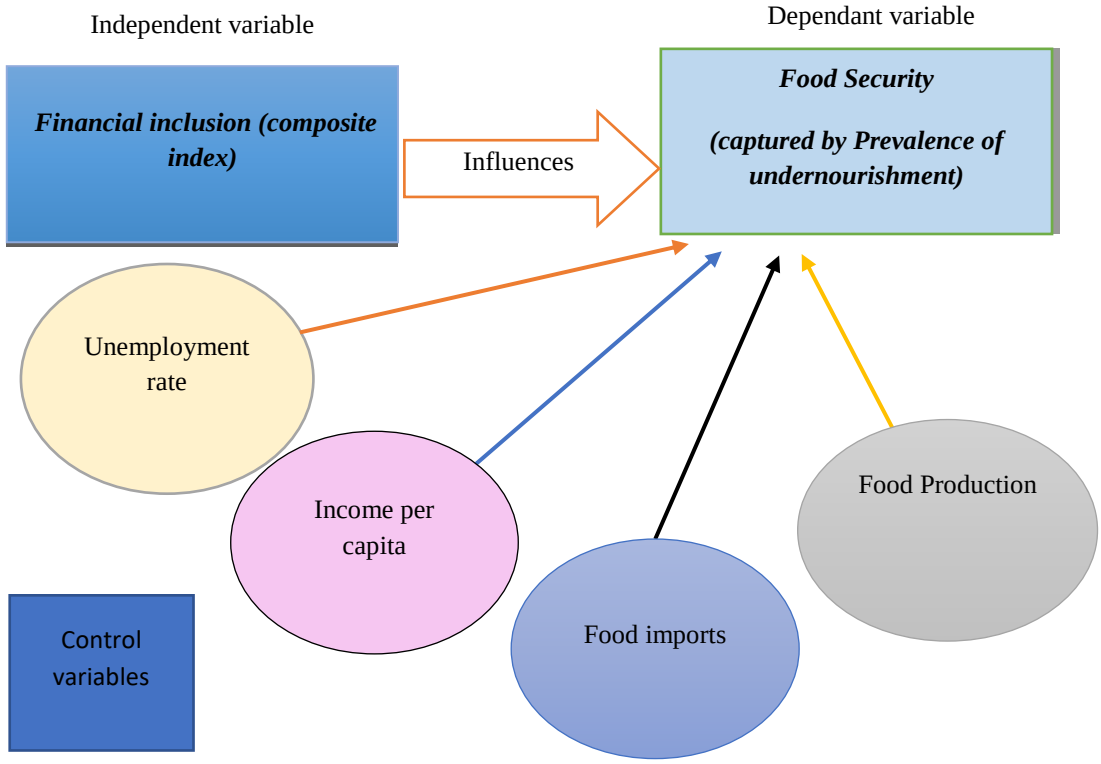
variable of financial inclusion and the dependent variable of food security, all while considering several control variables.

The independent variable, financial inclusion (FI), is captured using a comprehensive composite index derived from PCA. This index incorporates various indicators that gauge the accessibility and utility of financial services, spanning from credit and savings to insurance and digital payment systems.

On the other hand, the dependent variable, food security (FS), is operationalized by the prevalence of undernourishment. This metric reflects the proportion of the population unable to acquire sufficient and nutritious food to meet their dietary requirements.

Furthermore, the study includes several control variables to account for potential confounding factors. These control variables encompass unemployment (UEM), food imports (FIM), income per capita (INCAPITA), and food production (FoP).

Figure 2.1: Conceptual framework



Source: Author's own construction

b. Empirical literature

The intricate relationship between financial inclusion and food security has been explored empirically, yielding insights into dimensions and pathways that shape this connection. Notably, a literature review by CGAP found strong evidence of financial inclusion's positive impact on food security, particularly for women, offering potential policy implications (Sai Krishna & Bin-Humam, 2019).

The empirical literature presents a rich tapestry of research exploring the intricate nexus between financial inclusion and food security. These studies collectively reveal both unique dimensions and shared pathways that shape this complex relationship. In a reverse exploration, Koomson et al. (2022) delve into the multifaceted dimensions of financial inclusion's impact on food security. Their investigation underscores the pivotal role of entrepreneurship as a conduit, particularly in male-headed and rural households. Similarly, Baborska (2018) contributes by uncovering varying effects of different financial services on food security experiences, highlighting the nuanced attributes that shape these outcomes. This mirrors Arshad's(2022) study, which enriches the discourse by introducing a novel dimension—non-life insurance—underscoring the intricate role of a country's financial sector in bolstering food security.

In a distinct vein, the study by Huang & Nik Azman (2023) shines a spotlight on the transformative potential of digital inclusive finance. Their findings emphasize the complementary role traditional finance plays in amplifying the impact of digital inclusive finance on food security, echoing the integrated nature of financial solutions. Moreover, Ingutia and Sumelius(2022) dissect the often-overlooked dynamics of gender and cooperative membership. This spotlight on cooperative membership as a means of enhancing food security resonates with the overarching pursuit of equitable development, much like the overarching theme of financial inclusion's potential for societal betterment.

Enilolobo et al. (2022) further diversify the discourse by examining diverse determinants of food security. Their model's comprehensive exploration of variables spanning from labor input to environmental quality elucidates the intricate interplay of factors shaping food security outcomes. Paralleling this, the findings of Sagbo & Kusunose(2020) emphasize the potential role of lending practices in shaping positive food security outcomes. Both studies underline the significance of systemic factors in influencing food security, broadening the lens of inquiry.

Expanding this scope, Sulemana et al.'s (2019) study contributes a cross-country perspective by examining international remittances' impact on food security across Sub-Saharan Africa. This distinctive approach underscores a positive link between remittances and enhanced food security, with remittance frequency holding particular importance. Amidst this comprehensive landscape, certain dimensions of this

relationship have yet to be fully explored. For instance, a new dimension is illuminated by the potential positive impact of microfinance on nutrition, as evidenced by longitudinal studies conducted in Ghana and South Africa (Arouri et al., 2014). This nutritional facet not only supplements the broader discourse on food security but also emphasizes the holistic nature of overall well-being.

In the realm of empirical research exploring the intricate interplay between financial inclusion and food security, significant gaps have emerged. While various studies have shed light on dimensions and pathways, a comprehensive understanding within Algeria's specific context is lacking. This study aims to bridge this gap by investigating the nuanced dynamics of this relationship within Algeria, providing insights tailored to its unique economic, social, and cultural landscape. Additionally, gaps exist in comprehending the holistic impact of a composite financial inclusion index, assessing long-term effects, exploring urban-rural disparities, considering government policies, and ensuring data quality. Addressing these gaps will contribute to a more thorough comprehension of the implications of financial inclusion on food security in Algeria.

c. Overview of the literature

The intersection of financial inclusion and food security has become a focal point in sustainable development research. This overview integrates both the conceptual framework and relevant empirical literature, offering insights into the complex relationship between these two critical factors within the Algerian context.

The conceptual framework, as outlined in Figure 2.1, forms the basis of this study. It defines financial inclusion as the independent variable, measured through a composite index derived from Principal Component Analysis (PCA). This comprehensive index considers various indicators, reflecting the accessibility and usage of financial services. On the other side of the framework, food security is depicted as the dependent variable, operationalized by the prevalence of undernourishment. This metric captures the proportion of the population unable to access adequate and nutritious food. Control variables, such as unemployment (UEM), food imports (FIM), income per capita (INCAPITA), and food production (FoP), are integrated to address potential confounding factors.

Empirical research enhances our understanding of this relationship. Sai Krishna & Bin-Humam (2019) underscore the positive impact of financial inclusion on food security, particularly among vulnerable populations. Koomson et al. (2022) delve into entrepreneurship as a key link between financial inclusion and food security, particularly in rural and male-headed households. Baborska (2018) and Arshad (2022) reveal nuances in the effects of various financial services on food security.

Huang & Nik Azman (2023) highlight the transformative potential of digital inclusive finance, emphasizing its synergy with traditional finance. Ingutia and Sumelius (2022) bring attention to the dynamics of gender and cooperative membership in enhancing food security. Enilolobo et al. (2022) and Sagbo & Kusunose (2020) explore systemic factors and cross-country perspectives, underlining their influence on food security outcomes.

While this global body of research provides crucial insights, Algeria's specific context presents unique challenges. Hence, this study aims to fill gaps in the literature by examining how financial inclusion impacts food security within Algeria. It provides tailored insights for policymakers and stakeholders, fostering informed decisions and sustainable development. As such, this concise literature overview merges the conceptual framework with empirical evidence, offering a comprehensive understanding of financial inclusion's impact on food security in Algeria. It underscores the need for context-specific research to inform sustainable development strategies in the nation.

3. Methodology

This study presents a comprehensive evaluation of the profound impact of financial inclusion on food security within the unique socio-economic context of Algeria. Our investigation spans a substantial period, encompassing the years from 2003 to 2021. Algeria, as our chosen case study, is underpinned by its strong commitment to sustainable development, particularly focusing on enhancing human well-being by improving living conditions and alleviating hunger. Within this holistic development framework, financial inclusion emerges as a central and transformative element.

a. Variables and data sources

The study used quantitative methods and collected data series from a variety of sources. Data for financial inclusion, the independent variable, are obtained from different global data bases, including the FMI's Financial Access Survey and the World Bank's database, as well as the Central Bank of Algeria (BA). On the other hand, the data on food security (the dependent variable), proxied by undernourishment rate and all the control variables are collected from World Bank's World Development Indicators. The variables employed in this study are indicated in the table below:

Table 3. 1: Variables employed in the current study

Variable	*Description*	*Measurement*
Prevalence of Undernourishment (FS)	The percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life (World Bank, n.d.)..	% of population
Financial Inclusion (FI)	Financial inclusion, per the World Bank (2022), means affordable, useful financial services for all - transactions, payments, savings, credit, and insurance. financial inclusion evolved from a binary concept, classifying individuals and enterprises as either included or excluded, into a multidimensional concept recognizing the diverse needs and circumstances of different segments of society (Demirgüç-Kunt et al., 2013)	Proxied by a composite index (calculated through a two steps PCA method using access and usage proxies)
Unemployment (UEM)	Unemployment refers to the share of the labour force that is without work but available for and seeking employment (World Bank, n.d.).	% of total labour force
Income per capita (INCAPITA)	GDP per capita is the Gross Domestic Product (GDP) divided by the midyear population(World Bank, n.d.).	**(**current US$**)**
Food Imports (FIM)	Food comprises the commodities in SITC sections 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels).(World Bank, n.d.)	% of merchandise imports
Food production (FOP) (Food production index (2014-2016 = 100))	Food production index covers food crops that are considered edible and that contain nutrients (World Bank, n.d.)	

Source: Author's compilation

b. Construction of Composite Financial Inclusion Index

This study measures the level of financial inclusion by developing two dimensional proxies and a composite financial inclusion index, and then assessing the effect of financial inclusion on the country's food security. To construct the Financial Inclusion (FI) Composite Index, a meticulous two-step Principal Component Analysis (PCA) process is employed. This approach simplifies the measurement of financial inclusion while retaining its essential characteristics (Cámara & Tuesta, 2014). The access and usage indices, in addition to the composite financial inclusion index are calculated using PCA and normalized such that the value of zero and one representing worst and best score. As such, the minimum and maximum values for financial inclusion are zero and one, in that order.

Step 1: Development of Financial Access and Financial Usage Indices

The first step entails deriving financial access (AC_i) and financial usage (US_i) indices through PCA. This process combines multiple indicators into concise indices that encapsulate the core features of financial access and usage. Specifically, the access dimension (AC_i) is calculated using the number of bank branches ($BBsP_i$) and ATMs ($ATMs_i$) per 100,000 people, while the usage dimension (USi) integrates indicators such as deposits as a percentage of GDP ($DepoGDP_i$), credits as a percentage of GDP ($CreGDP_i$), domestic credit to the private sector as a percentage of GDP ($DCPS_i$), and borrowers from commercial banks per 1,000 adults ($BFCB_i$). By postulating that access and usage are linearly determined, equations 3.1 and 3.2 are used to compute their indices.

$$AC_i = \beta_1 BBsP_i + \beta_2 ATMs_i + \mu_i \quad (3.1)$$

$$US_i = \alpha_1 DepoGDP_i + \alpha_2 CreGDP_i + \alpha_3 DCPS_i + \alpha_4 BFCB_i + \varepsilon_i \quad (3.2)$$

Step 2: Construction of the Financial Inclusion (FI) Composite Index

The second step involves creating the Financial Inclusion (FI) Composite Index by combining the access and usage dimensions. This is achieved through a linear combination, as expressed in Equation 3.3:

$$FI_i = w_1 AC_i + w_2 US_i + e_i \quad (3.3)$$

Where FI_i represents the overall financial inclusion index for a given year (i), AC_i is the access dimension, and US_i signifies the dimension for financial usage. The weights (w_1 and w_2) are determined by the eigenvalues of the principal components, while e_i accounts for the error term. The two-step PCA process efficiently condenses multidimensional financial inclusion data into a single, comprehensive index, facilitating a holistic assessment of financial inclusion in the Algerian context.

c. Empirical Model Specification

The empirical analysis in this study is conducted using a Vector Error Correction Model (VECM). The VECM is a widely employed econometric framework for exploring the long-term and short-term relationships among variables, especially in cases of non-stationary time series data. Given the dynamic nature of financial inclusion and its potential impact on food security in Algeria, the VECM is a suitable choice for modelling these complex relationships.

The VECM model is a restricted vector autoregression (VAR) model because the data is not stationary at the level but at the first difference. However, there is a cointegrated relationship between variables in the system (Saraswati et al., 2020). The VECM hence, is an extension of the Vector Autoregressive (VAR) model, designed to handle cointegrated time series data. Cointegration implies a long-run equilibrium relationship among variables, even if they exhibit short-term fluctuations. In this context, the VECM allows us to examine both the short-term dynamics, as well as the long-term equilibrium relationships among financial inclusion, food security, and other relevant variables.

The Vector Error Correction Model (VECM) is indeed composed of a Vector Autoregressive (VAR) model of the order p - 1 on the differences of the variables, along with an error-correction term that arises from the established cointegrating relationship between the variables. This framework is commonly used to analyse the long-term relationships among variables and their short-term dynamics in response to deviations from these relationships (Berlinger et al., 2015). The basic structure of the VECM involves specifying the following equations:

- **The cointegration equation**: It describes the long-term equilibrium relationship among the variables:

$$\Delta y_t = \propto + \beta_1 \Delta X_{1,t-1} + \beta_2 \Delta X_{2,t-1} + \cdots + \beta_k \Delta X_{k,t-1} + \varepsilon_t \qquad (3.4)$$

In this equation:

Δy_t: represents the differenced dependent variable. $\propto$: is the intercept. $\beta_1 \ldots \beta_k$: are the cointegration coefficients. $\Delta X_{1,t-1} \ldots \Delta X_{k,t-1}$: are the lagged differenced independent variables. ε_t: the error term.

- **Short-Run Dynamic Equations**: These describe how the variables adjust to deviations from the long-term equilibrium and are represented as:

$$\Delta y_t = \gamma_0 + \gamma_1 \Delta Y_{t-1} + \beta_1 \Delta X_{1,t-1} + \beta_2 \Delta X_{2,t-1} + \cdots + \beta_k \Delta X_{k,t-1} + \varepsilon_t \quad (3.5)$$

Here:

γ_0: is the intercept.

ΔY_{t-1} : represents the lagged differenced dependent variable.

$\gamma_1$measures the speed of adjustment to restore equilibrium.

$\beta_1 \ldots \beta_k$: are the short-run coefficients.

Other variables remain as previously defined.

Modifying model 3.4 and model 3.5 to incorporate the study's variables, namely food security (FS) captured by the prevalence of undernourishment, index of financial inclusion calculated based on a two steps PCA, and control variables yield long run model 3.6 and short run model 3.7 for our objective which is about analysing the effect of financial inclusion on food security.

$$\Delta FS_t = \alpha + \beta_1 \Delta UEM_{t-1} + \beta_2 \Delta INCAPITA_{t-1} + \beta_3 \Delta FIM_{t-1} + \beta_4 \Delta FOP_{t-1} + \beta_5 \Delta FI_{t-1} + \varepsilon_t \quad (3.6)$$

$$\Delta FS_t = \gamma_0 + \gamma_1 \Delta Y_{t-1} + \beta_1 \Delta UEM_{t-1} + \beta_2 \Delta INCAPITA_{t-1} + \beta_3 \Delta FIM_{t-1} + \beta_4 \Delta FOP_{t-1} + \beta_5 \Delta FI_{t-1} + \epsilon_t \quad (3.7)$$

4. Financial Inclusion Trends in Algeria and Their Impact on Food Security

a. The Overall Financial Inclusion Trends

The analysis and the figure 4.1 bellow are performed using the output of the PCA method (see the appendix). Figure 4.1 indicates the trend for the overall composite index for financial inclusion in Algeria over the period 2003 to 2022. As shown, the trend for financial inclusion has on average been increasing over the same period. Between 2003 and 2006, financial inclusion declined from 0.097 to 0 before progressively rising from 0 to 0.218 in 2009. Thereafter, it sharply declined to 0.089 in 2011 indicating the impact of the financial global crisis experienced 5 years earlier.

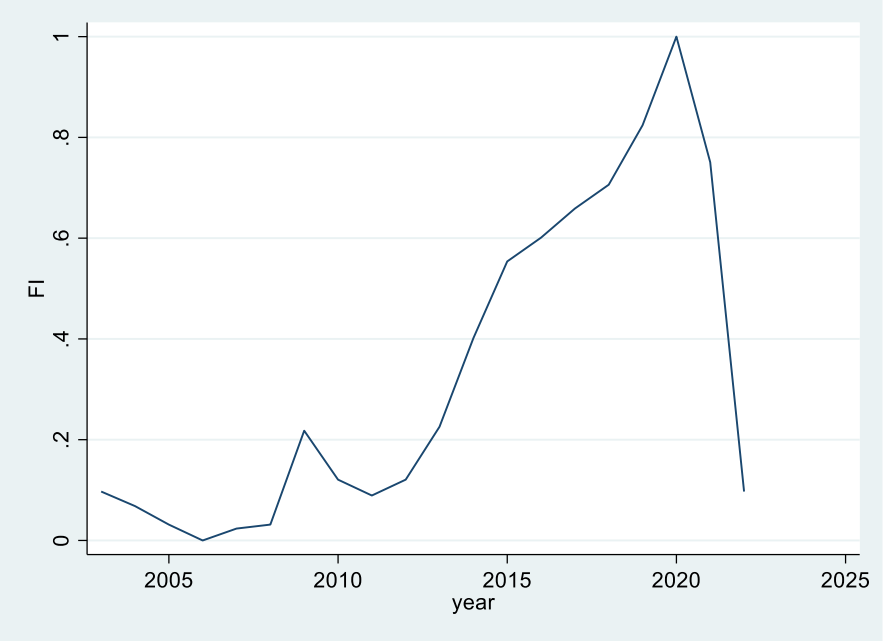
From 2011 to 2020, the trend line exhibited an impressive and consistent upward trajectory, reflecting a remarkable growth of 1,023% on average. This remarkable expansion could be attributed to a confluence of factors, including policy adjustments, targeted initiatives, and an increasingly favourable economic environment. This period of substantial growth in financial inclusion underscores the concerted efforts made to ensure that a larger proportion of the population gains access to and benefits from financial services.

However, the year 2021 brought about a notable reversal in this upward momentum, with the composite index experiencing a 25% decline. A decline which spread to the next year. This decline likely reflects the disruptive impact of the global COVID-19 pandemic, which introduced unprecedented challenges to both the domestic and global economies. The pandemic-induced economic fluctuations and uncertainties might have

temporarily hindered the forward march of financial inclusion, causing the observed contraction in the index.

In summation, figure 4.1 encapsulates the dynamic journey of financial inclusion in Algeria, showcasing periods of growth, setbacks, and resilience. It highlights the interplay of local and global factors, policy dynamics, and economic events that collectively shape the trajectory of financial inclusion efforts. The upward trends signify progress, while the downturns underscore the need for adaptive strategies to ensure sustained and inclusive financial development, even in the face of unforeseen challenges

Figure 4. 1 Performance of the overall composite index of financial inclusion



Source: Author using data from World Development Indicators.

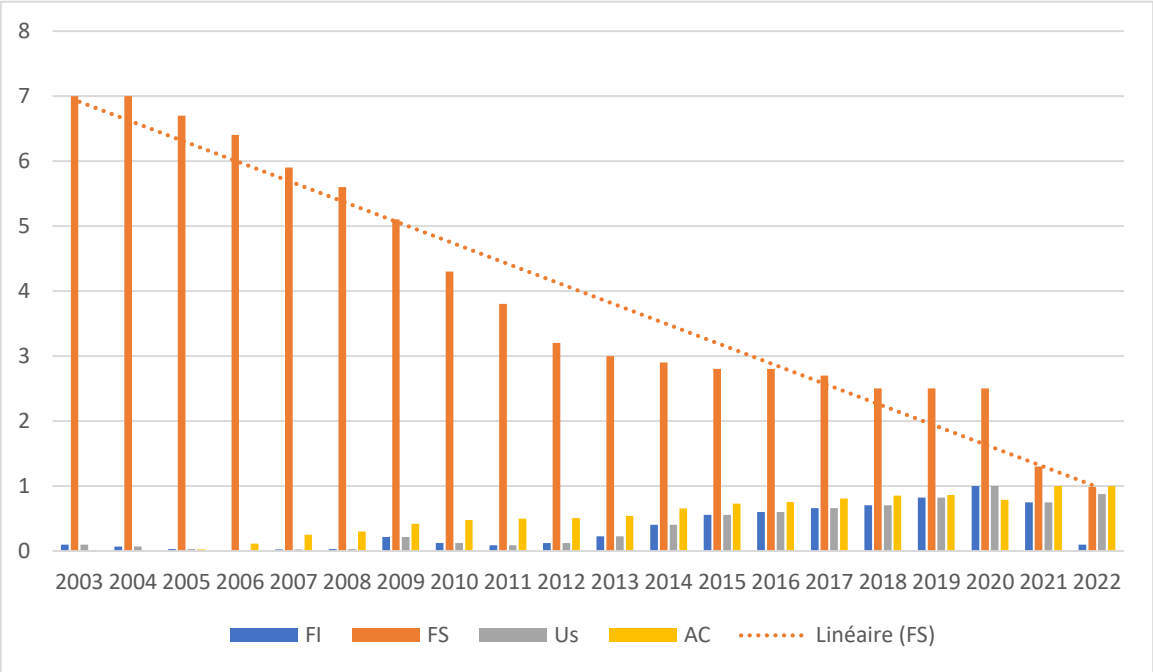
N.B. CFII: Composite Financial Inclusion Index

b. Financial inclusion and food security in Algeria

Figure 4.2, where the results of the PCA are also used, indicates the trends of financial inclusion and food security in Algeria from 2003 to 2022. As indicated, food security (FS) proxied by prevalence of undernourishment shows continuous decrease over the years. On the other hand, the overall financial inclusion index consistently improved in Algeria. Similarly, financial access and usage has also increased in Algeria. The increase in access is largely explained by increased number of ATMs per 100,000 people than the increase in the number of bank branches per the same number of people. Regarding increased financial usage, the large share is explained by increases in deposits and credits as a share of GDP while domestic credits to the private sector and borrowing from commercial banks equally contributed to the improvements in the

overall financial usage index. The ultimate measure of financial inclusion oscillated between 2003 and 2022, thereafter, it steadily increased between 2012 and 2020 before falling in by the years 2021 and 2022. This is attributed to the aftermath of the pandemic that affected banking transactions by restricting movements for people.

Figure 4. 2: Financial inclusion and food security over time



Source: Author construction

5. Presentation and Discussion of Results

a. Descriptive statistics

Table 5.1 presents descriptive statistics for several key variables. In terms of food security, the data comprises 20 observations with a mean score of approximately 3.95 and a standard deviation of roughly 1.91. Food security scores range from a minimum of 0.99 to a maximum of 7, indicating variations in food security levels. Regarding financial inclusion, the mean score is approximately 0.33, with a standard deviation of around 0.32. This variable is binary, with values of 0 and 1, suggesting that the dataset represents a mix of individuals with and without financial inclusion. The unemployment rate exhibits an average of 12.17% and a standard deviation of approximately 3.37%, with values ranging from 9.82% to 23.72%. Agricultural land holdings, on average, amount to 412,938 acres, with a standard deviation of approximately 3,462.79. The smallest holding is about 399,057 acres, while the largest

extends to 416230.1 acres. Income per capita averages around 4131.39 units, with a standard deviation of roughly 954.02. The minimum income per capita recorded is 2117.05 units, while the maximum is 5,610.73 units. In terms of food imports, the mean is about 19.69 units, with a standard deviation of approximately 1.64. Imports range from a minimum of 16.30 units to a maximum of 22.79 units. Finally, food production exhibits an average of 86.76 units and a standard deviation of approximately 22.17 units, with values spanning from 53.29 units to 121.25 units. These descriptive statistics provide an overview of the central tendency, dispersion, and range for each variable in the dataset.

Table 5. 1 Results for descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Food security	20	3.9491	1.9066	0.9854	7
Financial Inclusion	20	0.3309	0.3224	0	1
Unemployment	20	12.1655	3.3687	9.82	23.72
Agricultural Land	20	412938	3462.791	399057	416230.1
Income per capita	20	4131.391	954.0168	2117.048	5610.733
Food imports	20	19.6891	1.6432	16.301	22.79211
Food production	20	86.7580	22.1652	53.29	121.2516

Source: Author using data from World Development Indicators.

b. Diagnostic tests

Stationarity

Table 5.2 , bellow, presents the results of the Augmented Dickey-Fuller unit root test for several key variables, including Financial inclusion (FI), Unemployment (UEM), Income per capita (INCAPITA), Food imports (IMP), and Food production (FOP). The tests were conducted both with and without a drift term, aimed at assessing the stationarity of time series data. Notably, Financial inclusion (FI) is found to be stationary at the 10% significance level when considering first differences and with the inclusion of a drift term. Meanwhile, Food security (FS) and Food production (FOP) exhibit non-stationarity at the level, but they became stationary when considering first differences, with or without a drift term. Unemployment (UEM) is stationary at lag 2, irrespective of whether a drift term is included or not, and Food imports (FIM) also display stationarity at lag 2 in both scenarios. Finally, Income per capita (INCAPITA) initially exhibits non-stationarity at the level, but it shows stationarity at first difference even without the inclusion of drift terms.

Table 5. 2 Augmented Dickey-Fuller unit root test results

		No drift	drift
Variable	Lag	*I*(1)	*I*(1)
Food security (FS)	1	3.520***	-1.912**
Financial inclusion (FI)	2	-1.388	-1.388*
Unemployment (UEM)	2	-3.034**	-3.034***
Income per capita (INCAPITA)	1	-2.988**	-2.332**
Food imports (FIM)	2	-3.078**	-3.078**
Food production (FOP)	1	-3.210**	-3.210***

Source: Autor calculation

*, ** and *** represent significance at 10%, 5% and 1% respectively.

Cointegration tests

The tests for cointegration are necessary to determine the existence of the long run relationship among variables. For testing cointegration among integrated series, this study has applied the Johansen cointegration tests. The test has revealed the presence of at least three cointegrating relationships among the variables, indicating a long-term connection among them. This is a crucial finding as it suggests that changes in these variables are not temporary but rather have lasting effects on each other. Therefore, the results of the Johansen cointegration test provide strong justification for employing a Vector Error Correction Model (VECM) in this research. By choosing a VECM, we are appropriately modelling this long-term interdependence, which is essential for capturing the dynamic relationships in our data accurately. This modelling approach enables us to examine both short-term dynamics, as indicated by the lag coefficients, and long-term equilibrium relationships among the variables, providing a comprehensive understanding of how financial inclusion, food security, and other factors interact over time.

Table 5. 3 Johansen cointegration test

				research Objective	
Maximum rank	Params	LL	Eigenvalue	Trace statistics	critical value 5%
0	7	-204.0676	. .	1013.0739	94.15
1	20	40.1466	1.0000	524.6452	68.52
2	31	271.2053	1.0000	62.5280	47.21
3	40	287.9441	0.8604	29.0504*	29.68
4	47	296.4238	0.6312	12.0910	15.41
5	52	300.3261	0.3681	4.2864	3.76
6	55	302.4693	0.2228		

Source: Author using data from World Development Indicators.

* selected rank

d. Presentation of empirical results

The overall objective of this study is to analyse the impact of financial inclusion on food security in Algeria. Specifically, we focused on examining the effect of the composite financial inclusion index on food security proxied by prevalence of undernourishment. To achieve this, we employed the vector error correction model (VECM) as the suitable estimation technique for analysing the data. The results, provided in Table 5.4 and 5.5, show the long run and short run effects of financial inclusion on security.

As detailed in Table 5.4, in our long-run regression analysis, we sought to understand the intricate relationship between financial inclusion (FI), food security (FS) as proxied by the prevalence of undernourishment, and several other control variables. It's important to emphasize that in this context, a positive coefficient signifies higher levels of undernourishment prevalence, which consequently translates to reduced food security. Notably, the coefficient for Financial Inclusion (FI) stands out as highly statistically significant at the 1% level, featuring a positive beta value of 0.0148506. This robust finding indicates a counterintuitive, yet noteworthy, long-term relationship: as financial inclusion improves, it contributes to an increase in undernourishment, consequently diminishing food security. Additionally, the coefficient for Food Imports (FIM) also reveals a statistically significant positive relationship in the long run, further underscoring that heightened food imports correlate positively with increased undernourishment and, therefore, diminished food security. However, not all variables exhibit statistically significant effects. Unemployment (UEM) fails to demonstrate a robust long-term impact on food security, as reflected by a p-value of 0.100. Conversely, Income per Capita (INCAPITA) displays a statistically significant negative effect, indicating that higher income per capita is associated with lower undernourishment prevalence and, consequently, improved food security, with a beta value of -21.1459 and a p-value of 0.014. Lastly, Food Production (FOP), despite its positive coefficient implying increased undernourishment prevalence, is far from statistically significant with a p-value of 0.517. These findings shed light on the complex dynamics between financial inclusion, food security, and various other factors, emphasizing the need for a nuanced approach to improving food security within the context of economic development and policy interventions. These findings illuminate the intricate and, at times, counterintuitive dynamics between financial inclusion and food security, emphasizing the need for a nuanced approach to improving food security within the context of economic development and policy interventions.

Table 5. 4: Long run regression results for the effect of financial inclusion on food security.

Long Run				
Variable	Beta	Std.dev	t-Statistic	P-value
Financial inclusion (FI)	0.0148	0.0020	7.16	0.000
Unemployment (UEM)	0.1034	0.O629	1.64	0.100
Income per capita (INCAPITA)	-21.1459	8.6477	-2.45	0.014
Food imports (FIM)	0.0802	0.0184	4.34	0.000
Food production (FOP)	0.1781	0.2751	0.65	0.517
Error correction term	0.04367	0.0151	2.88	0.004
Constant	-0.2500	0.1670	-1.50	0.134

Source: Author using collected data.

In our short-run regression analysis (table 5.5), we explore the influence of financial inclusion (FI) on food security, represented by the prevalence of undernourishment. It's important to note again that, in this context, a positive coefficient implies an increase in undernourishment prevalence, leading to reduced food security. Financial inclusion, when considered with lag differences (LD), exhibits a noteworthy impact, with a coefficient of 0.4902 at LD, indicating that a one-unit increase in FI in the previous period corresponds to a 0.4902 unit increase in undernourishment prevalence, negatively affecting food security in the current period. This effect is statistically significant at the 10% level, though it lacks robustness. Intriguingly, the LD2 coefficient (2.8355) is highly significant, highlighting the substantial influence of FI changes from two periods ago on food security, albeit in a counterintuitive manner as FI is positively linked to undernourishment prevalence.

In contrast, the unemployment rate (UEM) displays significance only at LD, suggesting that a one-unit increase in UEM in the previous period results in a 0.7327 unit decrease in undernourishment, thereby improving food security in the current period—an unexpected outcome. However, this impact is not significant at LD2. Income per capita (INCAPITA) and food imports (FIM) both exert significant short-run effects on food security, with highly significant coefficients at LD and LD2, underlining their importance. For FIM, the LD coefficient is -0.7073, indicating that a one-unit increase in FIM in the previous period leads to a 0.7073 unit decrease in undernourishment prevalence, thus an improvement in food security in the current period. The LD2 coefficient for FIM is -0.6342, suggesting that a one-unit increase in FIM two periods ago results in a 0.6342 unit decrease in undernourishment prevalence, signifying enhanced food security. Conversely, food production (FOP) does not display significant short-run

effects on food security. These findings highlight the complex and occasionally unexpected dynamics between financial inclusion, unemployment, income per capita, food imports, and food production in the context of food security, underscoring the need for nuanced policy interventions to address these challenges effectively.

Table 5. 5 Short run regression results for the effect of financial inclusion on food security

Short Run				
Variable	Beta	Std.Dev	t-Statistic	P-value
Financial inclusion				
LD	0.4902	0.2816	1.74	0.082
LD2	2.8355	0.3826	7.47	0.000
Unemployment rate		0.5013	-1.46	0.144
LD	-0.7326	0.8836	0.14	0.889
LD2	0.1231			
Income per capita				
LD	-0.7958	0.2289	-3.48	0.000
LD2	-0.6617	0.1536	-9.23	0.000
Food imports				0.001
LD	-0.7073	0.1072	-6.59	0.000
LD2	-0.6341	0.0687	-4.31	
Food production			-	
LD	1.3130	0.9653	1.36	0.174
LD2	-1.9825	1.2657	-1.57	0.117
Error term	1.5595	0.6860	2.27	0.023

Source: Author using collected data.

6. Post estimation tests

- Unit Root Test for residuals

The results of the Dickey-Fuller test for unit root on the residuals of the VECM model indicate that the test statistic (Z(t)) is -3.642. To assess whether the series is stationary, the critical values at 1%, 5%, and 10% significance levels are compared to the test statistic. In this case, the test statistic falls below all three critical values, which suggests that we can reject the null hypothesis (H0) of a random walk without drift. This implies that the residuals are stationary, which is a favourable outcome for time series analysis. The results the Dickey-Fuller test for unit root for residuals suggest that the chosen

VECM model is robust. The stationary residuals indicate that the model effectively captures the underlying dynamics.

- **Multicollinearity**

The Variance Inflation Factor (VIF) values were computed to assess the presence of multicollinearity among the independent variables in the regression model. Multicollinearity, or high correlation between independent variables, can complicate the interpretation of each variable's unique contribution to the dependent variable. In this analysis, the VIF values for each variable were examined. While some level of multicollinearity was observed, none of the variables exhibited severe multicollinearity, as indicated by VIF values well below the threshold of 10. Unemployment Rate (UEM) had the highest VIF at 6.20, followed by Income per Capita (INCAPITA) at 4.87, Food Production (FOP) at 3.56, Financial Inclusion (FI) at 3.53, and Food Imports (FIM) at 1.89. The mean VIF for all variables was 4.01, confirming that although some correlation exists, it does not pose a substantial issue for the model's validity. Nevertheless, it is advisable to interpret the results cautiously, considering potential multicollinearity effects on coefficient estimates.

Table 6.1: Multicollinearity results using VIF

Variable	VIF	1/VIF
UEM	6.20	0.1612
INCAPITA	4.87	0.2040
FOP	3.56	0.2809
FI	3.53	0.2835
FIM	1.89	0.5287
Mean VIF	4 .01	

- **Normality**

The Skewness and Kurtosis tests for normality were conducted to assess the normality of the residuals. For skewness, the p-value is 0.9614, and for kurtosis, the p-value is 0.4168. In both cases, the p-values are well above the typical significance level of 0.05. Therefore, there is no strong evidence to reject the null hypothesis of normality for the residuals. The results of the normality tests on the residuals suggest that the chosen VECM model is robust. the normality of residuals enhances the reliability of statistical inference based on this model.

- **homoskedasticity**

Since the p-value (0.3946) is greater than the significance level (commonly set at 0.05), we fail to reject the null hypothesis. This means that there is no strong evidence to suggest that the residuals have heteroskedasticity. In other words, the assumption of constant variance in the residuals (homoskedasticity) is not violated.

7. Conclusion and policy implication

The findings of this study shed light on the complex interplay between financial inclusion and food security in Algeria over the past two decades. Our analysis utilized a composite financial inclusion index and the Vector Error Correction Model (VECM). This study provides a nuanced understanding of the intricate relationship between financial inclusion and food security in Algeria, offering valuable insights for policymakers and stakeholders. While the results may appear counterintuitive at first glance, they underscore the importance of crafting multifaceted, context-aware policies to address the country's unique challenges and opportunities.

Financial inclusion, often considered a beacon of economic progress, has paradoxically shown a negative impact on food security. This unexpected finding calls for a re-evaluation of the assumed benefits of financial inclusion. Policymakers should delve deeper into understanding the underlying mechanisms driving this effect. It might be the case that while financial inclusion promotes economic activities, it also spurs changes in consumption patterns, potentially leading to a decline in food security. Therefore, future policies should be designed to mitigate such unintended consequences, ensuring that financial inclusion genuinely enhances overall well-being, including food security.

On the other hand, the positive influence of unemployment rate (UEM) on food security can be attributed to Algeria's robust social safety nets and government support mechanisms, as well as to the expanding informal sector. The state's commitment to providing assistance to the unemployed, such as cash transfers, food aid, and employment support programs, has evidently contributed to maintaining food security during periods of economic hardship. To sustain this positive impact, policymakers should continue to strengthen these social safety net programs, making them more efficient and accessible to those in need. However, facing the informal sector through more inclusion strategies is a necessity.

Food imports (FIM), though paradoxically displaying a negative long-run effect on food security, emphasize the potential risk of overreliance on international markets to guarantee food security. While trade is essential for diversifying food sources, Algeria must be cautious not to become overly dependent on imports, as this could leave the nation vulnerable to global market fluctuations. Thus, policymakers should set a careful balance between fostering trade partnerships and ensuring domestic food production resilience.

The strong positive effect of income per capita highlights its pivotal role in enhancing food security. However, it also calls for attention to potential side effects. The phenomenon of Engel's law, where higher incomes lead to a smaller proportion of income spent on food, may signify dietary shifts that could negatively affect food security. Therefore, comprehensive policies should accompany income growth with measures to stabilize food prices and ensure that all segments of society benefit from economic prosperity.

Food production (FOP) has shown no significant impact on food security at both the short and long runs. This is despite the consented efforts, particularly through Saharan agriculture, and strengthening the relationship with the agri-food industry. This underscores the need for a multifaceted approach to addressing food security challenges, as economic growth and employment generation alone may not suffice.

Based on the above, addressing Algeria's food security challenges necessitates a multidimensional approach. Policymakers must tailor their strategies to account for the intricate interactions between financial inclusion, unemployment, income, and food imports. Additionally, investments in agriculture, rural development, and agro-industries are crucial to fortify the country's food security. This approach should preserve the nation's social character, ensuring justice, protecting vulnerable populations, and promoting balanced economic development across all regions. Ultimately, these steps are essential to secure Algeria's food sovereignty, economic stability, and social well-being in an increasingly complex global landscape.

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Appendix

Table 1: Normalised values of Access and Usage Indices and the composite financial inclusion index in Algeria between 2003 and 2022 (calculated based on PCA method)

years	FI	Us	AC
2003	0.0971115	0.0971115	0.0087035
2004	0.068242	0.0682421	0
2005	0.0314943	0.0314943	0.0236736
2006	0	0	0.1152804
2007	0.0236254	0.0236254	0.2521759
2008	0.031499	0.031499	0.3015818
2009	0.2178519	0.2178519	0.4178915
2010	0.1207387	0.1207387	0.4786195
2011	0.0892437	0.0892437	0.4971468
2012	0.1207397	0.1207397	0.5084689
2013	0.2257269	0.2257269	0.5393476
2014	0.4015794	0.4015794	0.6525694
2015	0.5538091	0.5538091	0.7287369
2016	0.6010495	0.6010495	0.7513812
2017	0.658793	0.658793	0.8090214
2018	0.7060375	0.7060375	0.8512223
2019	0.824148	0.824148	0.8615152
2020	1	1	0.7853478
2021	0.7506584	0.7506584	1
2022	0.0971115	0.87452468	1