

Cereal Trade and Food Security: Empirical Evidence for Sub-Saharan African Countries

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Abstract

Sustainable Development Goal 2 (SDG2) aims to end world hunger, but Africa is currently not on track to meet this goal. Sub-Saharan Africa is particularly affected, with a significant increase in undernourished people. The issue of food security is, therefore, a pressing concern, and promoting trade has been suggested as one solution. This study examines the impact of cereal import openness on the prevalence of undernourishment in 27 Sub-Saharan African countries for the period 2000 - 2020. Using a two-stage least square instrumental variable (2SLS-IV) estimator, we find that greater cereal import openness is significantly associated with higher levels of undernourishment in sub-Saharan Africa and then increased food insecurity. Our results are robust to alternative food security indicators.

Keywords: Food security, Cereal trade openness, Sustainable development goals, Sub-Saharan Africa

JEL Classification : F13 - Q17 - Q18

1. Introduction

Food security is defined as "a situation that exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Barrett, 2010; Shaw, 2007). Thus, food security means having enough food to eat regularly. As one of the Sustainable Development Goals, food security has been a global concern since 2015, with an increase in the number of hungry people worldwide. According to the Food and Agriculture Organization (FAO) of the United Nations (UN), between 720 and 811 million people worldwide faced hunger in 2020. This growing insecurity threatens people's livelihoods, especially the most vulnerable. The impact of the pandemic and the recent war between Ukraine and Russia have increased food insecurity in sub-Saharan Africa by at least 30 percent since early 2020 (Baptista et al., 2022). Despite reductions in hunger and poverty levels, over 26% of the global population still experiences moderate or severe food insecurity, with the majority in Asia and sub-Saharan Africa (WHO, 2022; UNICEF, 2021; WHO, 2021). Additionally, UN population projections suggest that the sub-Saharan African population will reach 2.2 billion by 2050, and the continent's fastest population growth could threaten food security.

In the early 2000s, African countries were already committed to improving food security by increasing their efforts in the agricultural sector. Then, in 2003, those countries committed to devoting 10% of the national budgetary resources to promoting the agricultural sector, citing its importance for improving food security. This commitment is known as the Maputo Declaration. However, this commitment has not been sufficient to improve food security. More recently, this commitment has been reaffirmed in the Malabo Declaration to end hunger in Africa by 2025. We can also note the existence of sub-regional organizations, such as the Network of Farmers Organizations and Agricultural Producers of West Africa, which aim to provide rural and urban populations with sufficient quality and quantity of food.

In this context, many countries have recognized the importance of trade openness to ensure adequate food security and are increasingly reliant on international trade for food security (Sun and Zhang, 2021). The benefits of free trade are widely recognized in economic theory. Trade openness enables countries to better utilize their comparative advantages and contribute to economic growth, which can benefit poverty reduction and food security (Chikhuri, 2013). Moreover, trade openness can improve food security in Africa (Simola et al., 2022).

The connection between trade and food security has become a topic of greater interest, as trade could be one of the means to achieve the Sustainable Development Goals (SDGs). Specifically, Sustainable Development Goal 2 (SDG2) seeks to end hunger, attain food security, enhance nutrition, and promote sustainable agriculture. Target

2.1 of SDG2 aims to end hunger by 2030 and guarantee year-round access for all individuals, particularly the poor and vulnerable, including infants, to safe, nutritious, and adequate food¹.

Trade liberalization has been proposed as a potential solution to eradicate hunger and malnutrition. Trade can connect countries with comparative advantages in sectors such as agriculture, while consumers can access a broader range of nutritious foods. Additionally, trade liberalization is anticipated to boost income levels, reduce poverty, and enhance overall well-being. Trade openness can lead to better food availability and diversity (Burgess and Donaldson, 2010; Dorosh and Rashid, 2013; Baldos and Hertel, 2015; Anderson, 2016; Dithmer and Abdulai, 2017; Donaldson, 2018; Dithmer and Abdulai, 2020). Trade openness can mitigate food price volatility (Dorosh et al., 2009; McCorrison et al., 2013; Rutten et al., 2013). Promote lower input costs and increase agricultural productivity (Dithmer and Abdulai, 2017; Dávalos et al., 2020), new employment opportunities, and higher incomes (Houssa and Verpoorten, 2015; Montalbano et al., 2018). Trade can also increase the diversity of micronutrients and macronutrients (Wood et al., 2018). Therefore, we anticipate that trade liberalization will impact food security in developing countries.

Trade liberalization can also negatively impact food security in sub-Saharan Africa. Indeed, it can lead to a dependence on imported food which can lead to higher prices for local consumers. This could also affect local small-scale farmers (depending on the policy's design). The increased competition could also lead to greater fragility of domestic food supply and make small-scale farmers more vulnerable to foreign shocks. Trade liberalization can lead to a decrease in availability because of higher incentives to export (Dreze and Sen, 1990; Watts and Bohle, 1993; Devereux, 2009). The higher exposures to economic shocks due to trade liberalization can also lead to higher food prices (Headey, 2011; McCorrison et al., 2013; Rutten et al., 2013; Flachsbarth and Garrido, 2014; Mary, 2019).

However, considering trade as a whole may not be enough when it comes to food security. This is why we have decided to focus on cereal trade in our analysis. Cereals are the primary source of energy for more than 962 million people across sub-Saharan Africa². They are therefore essential to food security. Cereal trade can have both positive and negative effects on food security. Cereal trade can enhance access to food by importing cereals for countries with insufficient domestic production, and the diversification of the food sources but also generate income for farmers and countries through export cereals. On the other hand, the dependency on cereal imports can also negatively affect food security by making countries vulnerable to trade barriers, price fluctuations, and external shocks. While our focus is on cereal trade, this does

¹ United Nations 2030 Agenda for Sustainable Development

² OECD-FAO Agricultural Outlook 2016-2025

not imply that other food items or factors are unimportant. Other food items and factors also play critical roles in determining food security. However, cereals are often the staple food and a major source of calories in SSA, making their trade particularly significant for food security analysis.

Our analysis focuses on sub-Saharan African countries which face significant challenges related to food insecurity. More than one-third of the world's undernourished people, representing 282 million in 2020, are in Africa, an increase of 46 million more than in 2019 (FAO, 2021). The worsening situation is attributed to several factors, including ongoing conflicts, climate variability, and economic conditions. As a result, Africa is not making sufficient progress toward achieving the Sustainable Development Goal of ending hunger. It is, therefore, compelling to examine how cereal trade affects food security in this region of the world. Our objective is to investigate the impact of cereal trade on food security represented by the prevalence of undernourishment and to examine the effects of other economic and non-economic factors (represented by our control variables) on food security.

Previous studies have examined the impact of trade openness on food security in Africa (Chikhuri, 2013; Dithmer and Abdulai, 2017; Bonuedi et al., 2020). However, none of these studies have specifically considered cereal trade. Marson et al. (2023) in addition to considering total trade also took specific account of cereal trade. However, the study was not specific to sub-Saharan Africa. Then, the presence of countries such as Brazil, Russia, and Ukraine which are among the biggest cereal exporters of the world in their study could lead to some results that are not representative of the situation of the region. Most of the sub-Saharan African countries are net cereal importers. We therefore propose to focus on the sub-Saharan African region.

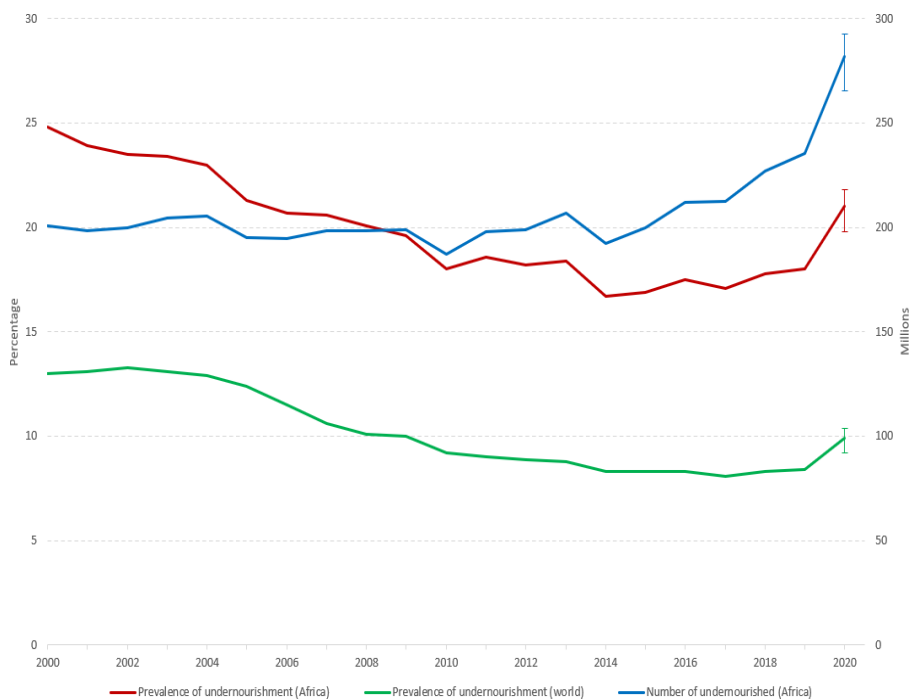
The remainder of the paper is organized as follows. Section 2 presents some stylized facts about food security trends in sub-Saharan Africa. Section 3 presents the theoretical framework, and Section 4 the literature review. Section 5 describes the data used and the methodology. Section 6 discusses empirical results. Section 7 concludes the paper.

2. Stylized Facts

Food security trend in Africa

To begin with, some stylized facts about African countries using Food and Agriculture Organization (FAO) data are informative. The prevalence of undernourishment (PoU) measure of hunger has significantly increased from 16.7% in 2014 to 21% in 2020, which is far higher than the world's prevalence of undernourishment at 9.9% in 2020 (Figure 1).

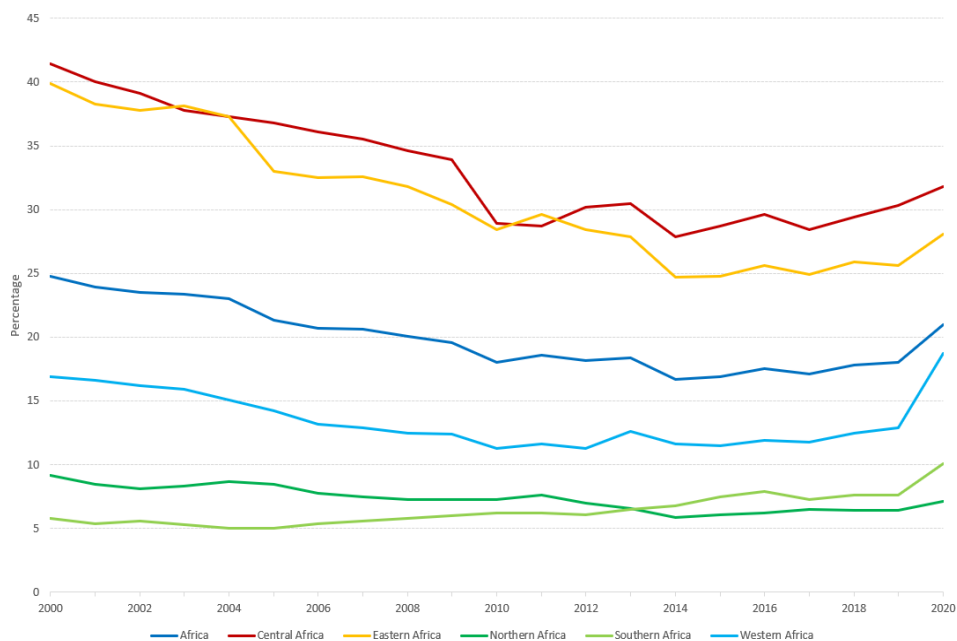
Figure 1: Prevalence of undernourishment in the World and Africa, and the number of undernourished in Africa



Source: FAOSTAT

A regional breakdown allows us to observe which part of the continent is more affected by food insecurity. Figure 2 shows North Africa is the least affected, with a Prevalence of Undernourishment of 7.1% in 2020, compared to 10.1% for Southern Africa, 18.7% for Western Africa, 28.1% for Eastern Africa, and 31.8% for Central Africa during the same period.

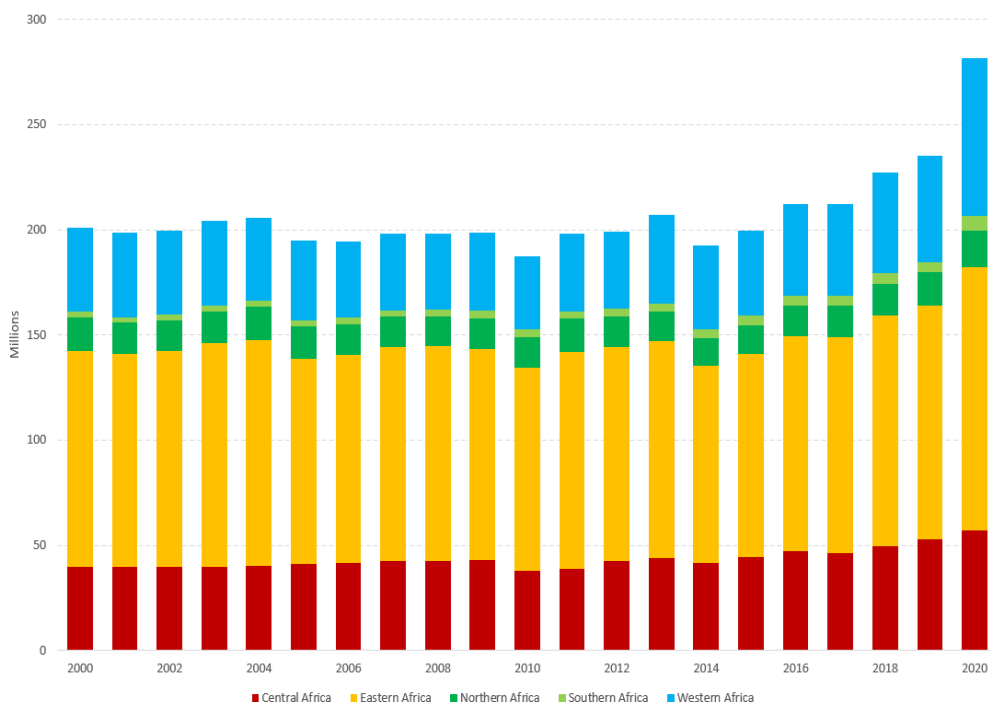
Figure 2: Prevalence of undernourishment in Africa by sub-region



Source: FAOSTAT

In terms of the number of undernourished individuals (Figure 3), this equates to 125.1 million people living in Eastern Africa, followed by Western Africa (75.2 million), Central Africa (57.1 million), Northern Africa (17.4 million), and Southern Africa (6.8 million). Food insecurity in many countries is driven by conflicts (ethnic fractionalization and religious conflicts) and adverse weather conditions (natural disasters).

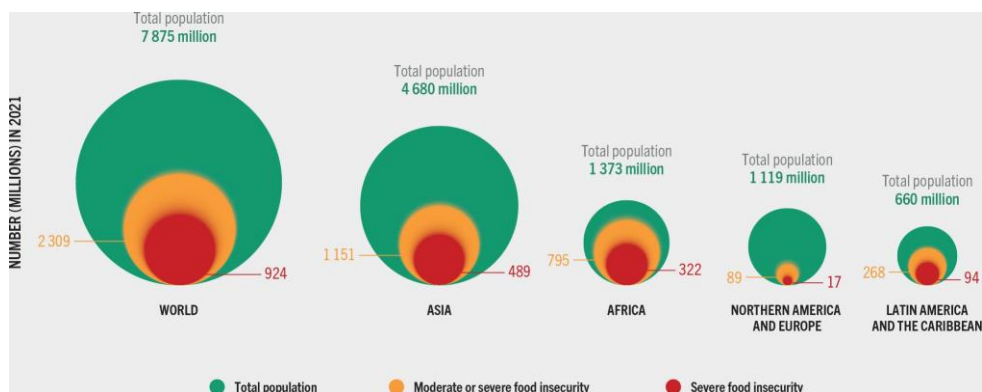
Figure 3: Number of people undernourished in Africa by sub-region



Source: FAOSTAT

Figure 4 displays food insecurity across different regions, indicating severity (moderate and severe). As shown, Africa is the second-most affected continent by food insecurity, behind Asia. Regarding moderate or severe food insecurity, 795 million people were affected in Africa in 2021. In terms of severe food insecurity, 322 million people were affected. These figures underscore the concerning state of food insecurity in Africa and the urgent need for solutions.

Figure 4: Food insecurity by severity and regions

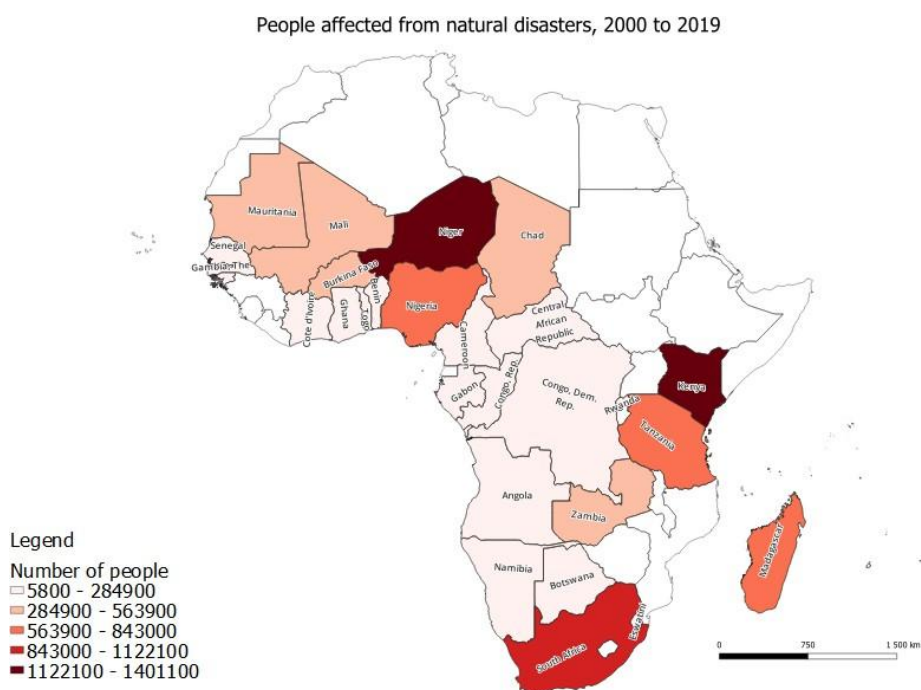


Source: FAOSTAT

Importance of climate

Climate has an important impact on food security, and we would like to highlight the resurgence of climate-driven natural disasters in Africa. Regardless of the type of disaster (biological, hydrological, meteorological, geophysical, or climatological), Africa is vulnerable to adverse impacts that can harm agriculture and aquaculture production, reducing food availability. Figure 5 depicts the total number of people affected by natural disasters during our study period from 2000 to 2019. Natural disasters include epidemics, wildfires, droughts, earthquakes, volcanic eruptions, storms, extreme temperatures, floods, and landslides. Natural disasters between 2000 and 2019 impacted all sub-Saharan countries in our database. The number of people affected ranged from 5800 to 1,401,100 people on average.

Figure 5: Total people affected by natural disasters, 2000 - 2019



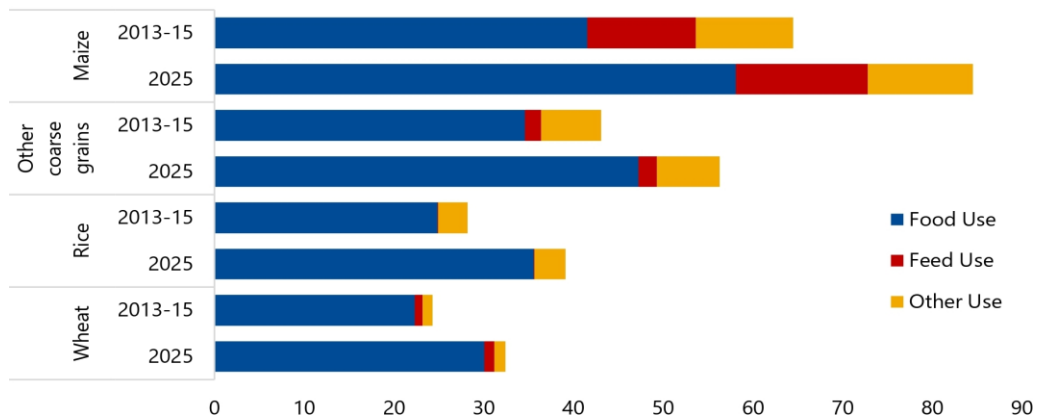
Source: Author's construction using data from EM-DAT database

Importance of cereals

As said previously, cereals are the primary source of energy for more than 962 million people across Sub-Saharan Africa³. Cereals are then important to food security in the region. Figure 6 shows the cereal consumption in Sub-Saharan Africa with a projection till 2025. As we can see, maize is the most important staple for consumption.

³ OECD-FAO Agricultural Outlook 2016-2025

Figure 6: Cereal demand composition



Source: OECD/FAO (2016), “OECD-FAO Agricultural Outlook”, OECD Agriculture statistics (database)

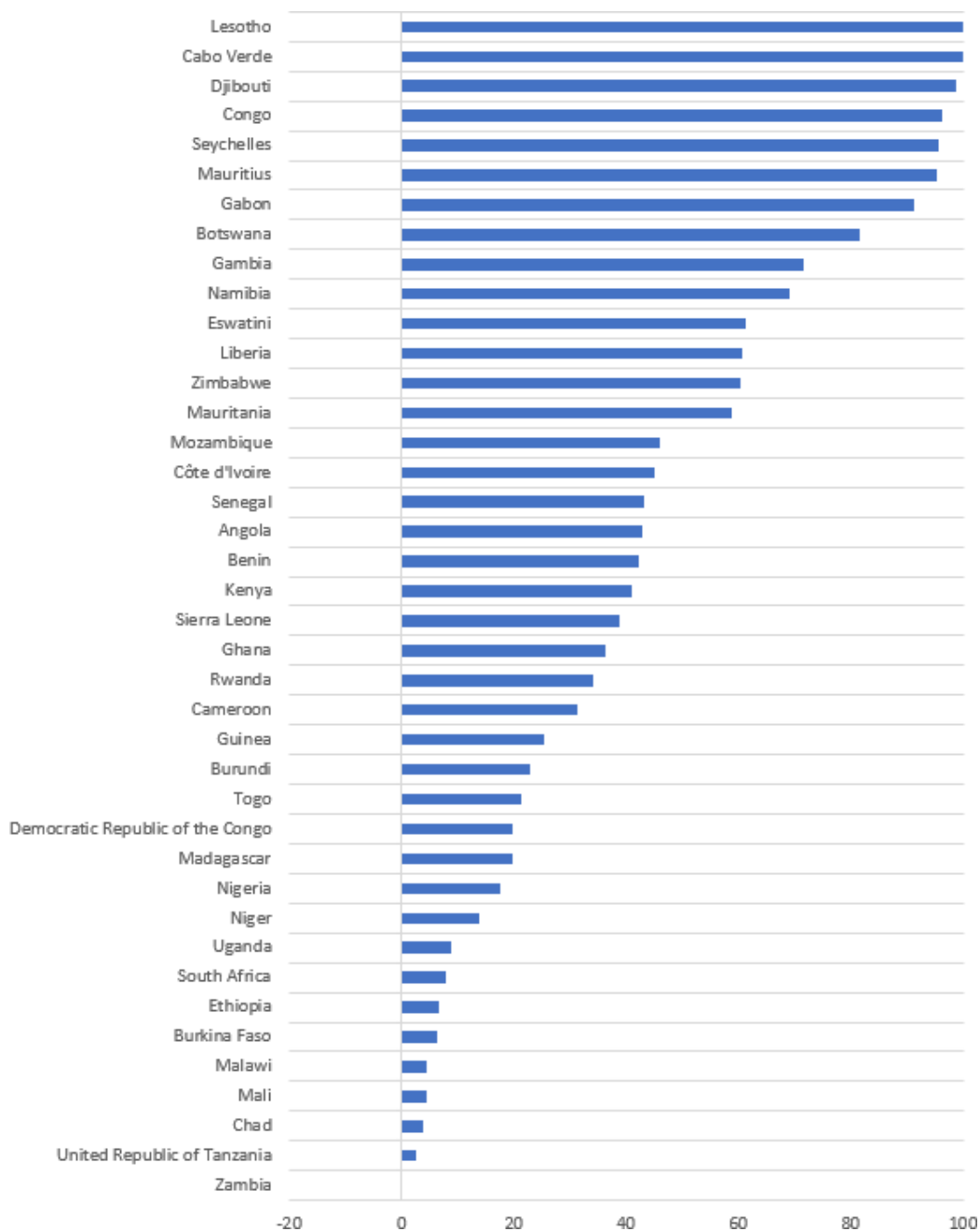
Cereal trade

About the cereal trade, many countries in sub-Saharan Africa are net importers of cereals. Despite efforts to increase domestic production, import dependency remains significant due to population growth, limited arable land, and low productivity. As we can see in Figure 7, the cereal imports dependency ratio⁴ developed by the FAO tells how much of the available domestic food supply of cereals has been imported and how much it comes from the country’s production. Negative values indicate that the country is a net exporter of cereals. Only Zambia presents a negative value indicating that Zambia is a net exporter of cereals in the region. This figure confirms then the high import dependence on cereal in sub-Saharan African countries.

⁴ It is computed as (cereal imports- cereal exports)/(cereal production + cereal imports- cereal exports)

* 100

Figure 7: Cereal import dependency ratio, 2018



Source: FAOSTAT

3.Theoretical Framework

This section explores the theoretical framework and the economic mechanisms through which trade affects food security. According to the Food and Agriculture Organization (FAO), food security is a multidimensional concept including availability, access, utilization, and stability. Availability means sufficient quantities of food of appropriate quality. Access refers to individuals with access to adequate resources for acquiring appropriate foods for a nutritious diet. The utilization of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met and stable meaning being food secure and refers to a population, household, or individual with access to adequate food at all times (FAO, 2003). Trade openness can affect food security and then each dimension of this concept. When it comes to the access dimension, trade openness can affect access to food via its effects on prices, the availability of production factors, economic growth, household incomes, and employment (Dithmer and Abdulai, 2017). Trade can contribute for example to more production factors through its effects on prices. The producers can also benefit from the increased demand for goods due to trade openness. Moreover, trade openness favors exports of products manufactured using a relatively abundant factor in most developing countries, namely (low-skilled) labor, thus creating employment opportunities (also for non-agricultural income) and increasing household incomes (Stolper-Samuelson theorem) (Dithmer and Abdulai, 2017).

According to Jaffee et al. (2011), this process can lead to a reduction in poverty and an increase in food security. Trade openness can also lead to more access to food products through food aid. The openness of a country may positively affect the possibility of receiving food aid (FAO, 2005). Alesina and Dollar (2000) for instance show that the direction of foreign aid is influenced by strategic considerations. Concerning the availability dimension, trade openness will allow countries access to larger markets and a diverse range of food products. Trade openness provides access to larger markets, offers opportunities for specialization in production, and dynamic efficiency gains through factors such as economies of scale, technology transfers, and knowledge spillovers, and thus improves opportunities to generate export revenues (Wacziarg and Welch, 2008). Trade may then lead to an increase in food products available for the population and a greater variety of goods. In addition, export earnings can be used to import production inputs such as machinery, fertilizers, and pesticides. However, debt servicing obligations and deteriorating terms of trade between agricultural products and manufactured goods can limit the scope for financing food imports for countries whose main source of foreign exchange is agricultural products (FAO, 2019).

Trade openness can also lead to food stabilization by mitigating situations of excess demand or supply on domestic markets, thereby stabilizing national food

supplies and reducing price fluctuations (Dithmer and Abdulai, 2017). A more open trade regime can therefore reduce the variability of (staple) food supply, as countries have more options for improving food availability than under a policy of self-sufficiency. It also relieves countries of some of the burden of costly stock maintenance interventions (FAO, 2000)

4. Literature Review

The importance of trade openness in maintaining adequate food security has been recognized by many countries, leading to extensive debates (Fusco et al., 2020). Trade openness provides access to larger markets, enabling specialization in production and opportunities to improve productivity and generate export earnings, realizing dynamic efficiencies such as economies of scale, technology transfers, and knowledge spillovers (Wacziarg and Welch, 2008). Trade can thus increase the total amount of goods, including food, available to the national population and enhance the variety of goods available (FAO, 2000). Despite the potential role of trade openness in achieving food security, more research is needed. However, only a few studies have analyzed the impact of trade on food security (Dithmer and Abdulai, 2017; Bonuedi et al., 2020; Sun and Zhang, 2021). Several case studies have examined the impact of trade reforms on food security (FAO, 2006), but they used poverty indicators instead of food security indicators (Dithmer and Abdulai, 2017). In the literature, there is a debate on the impact of trade on food security. Some authors argue that removing trade barriers can increase accessibility to the international market, reduce the price of imported goods, and provide availability and diversity of foods. For instance, Chikhuri (2013) found that international trade is a significant tool for reducing hunger in developing countries, based on their analysis of the impact of alternative agricultural trade liberalization strategies in the Sub-Saharan region.

In the same vein, some authors have analyzed the impact of trade on food security and found mixed results. Tanaka and Hosoe (2011) studied the impact of agricultural trade liberalization, specifically the rice trade, on Japan's food security. They found that rice trade liberalization increases welfare even during domestic productivity shocks. Protectionism of the domestic rice market will harm Japan's national food security rather than ensure it.

We also note the work of Dithmer and Abdulai (2017), who investigated the impact of trade openness on food security measured by dietary energy consumption. Their findings suggest that trade openness positively and significantly impacts food security, meaning that trade openness significantly contributes to food security. Moreover, FAO (2003) argues that trade openness has been consistent with food security by leading to lower food prices that benefit everyone, including the most severely food insecure, and more diverse diets that make the poorer classes less vulnerable to the unavailability of foodstuffs or the fluctuation of the prices of

certain foodstuffs.

Recently, Sun and Zhang (2021) estimated the impact of trade openness on food security in Central Asian countries. They found a U-shaped relationship between trade openness and food security, meaning that trade openness improves food security beyond a certain threshold in those countries. Always in Asia, Zakaria et al. (2016) empirically analyzed the effects of trade openness on undernourishment in South Asian countries. Results suggest that undernourishment has decreased after trade liberalization.

Similarly, the study by Bonuedi et al. (2020) investigated the impact of easing trade across borders on food security in Africa and found that poor trade facilitation contributes to food insecurity, implying that trade facilitation is an essential driver of food security. Furthermore, Fusco et al. (2020) examined the effect of trade openness on food security in European countries using two food security indicators. They concluded that trade openness has a significant impact on food security.

While some studies have found that trade openness can positively impact food security, others have suggested that it could lead to harm by making the food supply more dependent on imports and harming small farmers in developing countries. For instance, Tanaka and Hosoe (2011) found that trade openness could lower food self-sufficiency and make the food supply more dependent on imports, while Moon (2011) argued that agriculture could not be allowed to be freely traded due to its complex problems. Furthermore, Kang (2015) found that trade liberalization initially worsened food security in less developed countries, but the situation could be reversed with good policies. Protectionist policies have also been observed in response to increased hunger, as found by Mary (2019).

While there is a vast literature examining the impact of trade on food security, such as those conducted by Chikhuri (2013), Dithmer and Abdulai (2017), and Bonuedi et al. (2020), we do not have a lot of evidence concerning the impact of cereal trade on food security. We can mention the work of Tanaka and Hosoe (2011) which analyzed the impact of rice trade on Japan's food security and Marson et al. (2023) which analyzed the impact of trade on food security in developing countries while emphasizing the cereal sector. However, we do not find any sufficient evidence concerning the Sub-Saharan Africa region. Therefore, our study aims to fill this gap by examining the impact of cereal trade on food security in Sub-Saharan Africa.

5. Description of Data and Methodology

Data

Based on the previous literature and data availability, we used panel data for 27 sub-Saharan African countries covering the period 2000 - 2020. The data used in the study come from the World Bank's World Development Indicators (WDI) database, the EM- DAT⁵ database and the FAO's FAOSTAT.

Food security indicator and measuring cereal import openness

Food security is a multidimensional concept. Indeed, it can be divided into four dimensions namely availability, access, utilization, and stability. There is no single indicator representing all the dimensions at once. However, based on the research question, and the availability of the data, we measure food security using the prevalence of undernourishment from FAOSTAT in our study. The prevalence of undernourishment is defined as the proportion of the population whose habitual food consumption is insufficient to provide the dietary energy levels required to maintain normal activity and healthy life. This indicator provides insights into the number of individuals who do not have access to sufficient food to meet their basic nutritional needs. In our study, using the prevalence of undernourishment is relevant because it allows us to see the immediate impact of the cereal trade on the number of people suffering from undernourishment. In addition, this indicator is usually chosen in the literature on food security (Mary, 2019; Marson et al., 2023; Bonuedi et al., 2020). This indicator has also been used by the MDG and SDG initiatives to monitor the global fight against hunger (Marson et al., 2023; Mary, 2019).

In our analysis, we construct a measure of cereal trade using data on imports of cereals from the FAO database and GDP to measure the country's cereal import openness. Cereal import openness is measured by a country's cereal imports as a percentage of GDP. The two sides of trade can affect differently food security, and, in our analysis, we have decided to focus on cereal imports. This approach provides specific insights into a country's dependence on external sources for its food supply and how external dependencies shape food availability, accessibility, and affordability, informing more effective and resilient food security strategies. Also, nearly all Sub-Saharan African countries are net importers of cereals. So, by focusing on cereal import openness, we aim to quantify the impact of this dependency on food security. Understanding the implication of cereal import

⁵ The Emergency Events Database, by the Centre for Research on the Epidemiology of Disasters (CRED), part of the University of Louvain (UCLouvain)

openness is also essential to formulating effective trade policies. Considering cereal imports has been done in other studies such as Marson et al. (2023).

Control variables

We include several control variables usually used in the food security literature to account for various factors that may influence food security such as economic factors, agricultural factors, climate factors, demographic factors, and political factors.

(i) **GDP growth.** The annual percentage growth rate of GDP is used for the level of economic development. A negative relationship between GDP growth and the prevalence of undernourishment is expected since higher income levels generally increase the ability to purchase food and then reduce the number of people undernourished. Data for GDP growth is from the World Bank WDI database.

(ii) **Cereal yield.** The average cereal yield in kg per ha is used to measure agricultural productivity and is expected to positively affect food security. A negative sign of the prevalence of malnutrition is expected. Data for cereal yield is from the World Bank WDI database.

(iii) **Arable land.** Arable lands in the percentage of land area are used as a measure of the land used for crops and is also expected to affect positively food security. In our case, we expect a negative sign with our measure of food security. Data for arable land is from the World Bank WDI database.

(iv) **Political stability.** To account for the impacts of conflicts, we use political stability and absence of violence indicators from the World Governance Indicators database. A higher level in this indicator means more political stability and the absence of violence. We expect this variable to have a positive impact as better stability and the absence of conflicts should be beneficial to food security. In our case, a negative sign is expected.

(v) **Natural disasters.** To control the effect of climate on food security, a measure of the percentage of the population affected by natural disasters is used. We use data from the Emergency Events Database (EM-DAT) ⁶. The variable is computed as the number of people affected by natural disasters divided by the total population as in Dithmer and Abdulai (2017).

(vi) **Employment.** We also control the level of employment in agriculture as this sector is very essential for the improvement of the food security level in Sub-Saharan Africa. Data for employment in agriculture is from the World Bank WDI database.

⁶ Natural disaster comprises geophysical, meteorological, hydrological, climatological, and biological disasters (see <http://www.emdat.be/>).

(vii) **Population growth.** The annual population growth rate is used to control demographic impact. Data for population growth is from the World Bank WDI database.

(viii) **Inflation.** Inflation as measured by the consumer price index is used to control the quality of the macroeconomic environment. We expect a positive sign as an increase in prices should lead to higher levels of food insecurity. Data for inflation is from FAOSTAT.

Table 1 reports the summary statistics of the variables employed. The list of countries used in the analysis is the list of variables, and their sources are presented in the appendix.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Prevalence of Undernourishment (%)	567	18.51	9.74	3.4	49.5
Cereal import openness	567	1.33	1.15	0.05	9.07
Terms of trade (index)	567	95.39	18.41	18.69	158.06
Real exchange rate (index)	567	629.68	1229.31	0.544	9565.08
GDP growth	567	4.28	3.92	-20.80	15.37
Cereal yield (kg per ha)	567	1549.47	1257.22	0.1	9453.7
Arable land (% of land area)	567	17.03	14.26	0.32	525.24
Population growth	567	2.48	0.73	0.002	4.15
Political stability	540	-0.35	0.82	-2.40	1.22
Employment in agriculture	567	50.30	21.04	5.31	89.09
Inflation	554	5.89	6.34	-8.23	44.35
Natural disasters	544	0.54	3.29	0	43.33

Methodology

Our objective is to empirically analyze the impact of cereal trade openness on the prevalence of undernourishment in sub-Saharan Africa. Following the model developed by Bonuedi et al. (2020) and Mary (2019), we are using the following fixed effects model:

$$PoU_{i,t} = \alpha + \beta_1 CIO_{i,t} + \beta_2 X_{i,t} + \rho_i + \epsilon_{i,t} \quad (1)$$

where $PoU_{i,t}$ represents the prevalence of undernourishment of country i in year t ;

$C/O_{i,t}$ is the cereal import openness; $X_{i,t}$ is a vector of control variables namely the GDP growth, cereal yield, arable land, population growth, political stability, employment in agriculture, inflation, and natural disasters; ρ_i captures country-specific effects; $\epsilon_{i,t}$ is the error term.

Following the literature (Dithmer and Abdulai, 2017; Marson et al., 2023; Mary, 2019), we acknowledge the potential endogeneity problem mentioned by previous studies on the relationship between trade and food security. Endogeneity can arise because of reverse causality. Indeed, government actors can base their choices about cereal imports according to the levels of food insecurity in their countries.

To address this potential endogeneity, several econometric techniques can be used. One of these methods is the Generalized Method of Moments (GMM) estimator, as used by Dithmer and Abdulai (2017), which employs lagged values of explanatory variables as instruments. However, this method has been criticized for the possible weakness of instruments and its need for a large sample (Arellano and Bond, 1991). An alternative approach is the instrumental variable approach used by Mary (2019), Marson et al. (2023), and Bonuedi et al. (2020). In our paper, we perform the Instrumental Variable Two-Stage Least Squares (IV-2SLS) and control for country and time-fixed effects. This estimation technique is well suited to analyze structural equations that suffer from the problem of endogeneity, resulting from reverse causality between the dependent and the independent variables, and/or from omitted variable bias, and/or from measurement errors (Murshed, 2020). The main challenge in this approach is to find a good instrument for cereal trade, which must be correlated with cereal trade openness, exogenous to the prevalence of undernourishment, and relevant. Mary (2019) used rainfall anomalies as an instrument and Marson et al. (2023) used a measure of the rest of the world's trade openness as an instrument for trade openness. In their analysis, Bonuedi et al. (2020) used an instrument based on the distances between countries. They used the distance to the frontier (DTF) score of trading across borders.

To address this issue, we use two instruments in our analysis: the terms of trade and the real exchange rate as in Murshed (2020). The terms of the trade index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes. It is the ratio of a country's export prices to its import prices. The real exchange rate is the nominal effective exchange rate divided by a price deflator or index of costs. It adjusts the nominal exchange rate by relative price levels between countries, reflecting the competitiveness of a country's goods and services. Our instruments need to satisfy several requirements to be considered plausible. When it comes to the relevance requirements, favorable terms of trade (higher terms of trade) mean that a country can obtain more imports for a given number of exports, potentially increasing the volume of cereal imports. Concerning the real exchange rate, it affects the trade balance by influencing the relative prices of exports and imports, which in turn impacts on cereal import levels. And when

it comes to the exogeneity of our instruments, terms of trade are influenced by global commodity prices and external economic conditions rather than domestic cereal import policies or food security directly. Thus, it is likely to be exogenous to the prevalence of undernourishment. Concerning the real exchange rate, the fluctuations are driven by a variety of macroeconomic factors, such as inflation rates and monetary policies, rather than direct influences from domestic cereal import policies or food security status. As in Murshed (2020), we are using the natural logarithm of terms of trade and real exchange rate in our analysis.

However, we acknowledge that finding a proper instrument that meets the exogenous and endogenous criteria is a challenge. We verify the endogeneity of cereal import openness and the relevance of our instruments. The first stage of the IV-2SLS estimation is also investigated.

6. Results and Discussion

Cereal import openness and food security

In this section, we present and discuss the empirical results from the cereal trade and food security regression. It is important to remember that we use the prevalence of undernourishment as a measure of food security. So, a high level of this variable means less food security as the number of people undernourished will increase. So, for the interpretation of the sign of the coefficients, negative signs mean an improvement in food security as we will have fewer people undernourished. The results of the first-stage regression are presented in Table 5 in the appendix.

The second stage results showing the impact of cereal import openness on the prevalence of undernourishment are presented in Table 2. An endogeneity test is performed and confirms that cereal import openness is endogenous, hence the use of an instrumental variable estimator. The validity of our proposed instruments is assessed via the Anderson conical correlation Lagrangian Multiplier (LM) test for under-identification and the Cragg- Donald Wald F test for weak identification. The Sargan statistics for the overidentification of the instruments are also displayed.

Turning to the results, cereal import openness is positive and statistically significant. An increase in cereal import openness is associated with an increase in the prevalence of undernourishment. Higher cereal import openness is associated with an increased prevalence of undernourishment and then unfavorable food security improvement. This finding is in line with Mary (2019), Tanaka and Hosoe (2011), Moon (2011) and Kang (2015). This finding implies that greater reliance on cereal imports may lead to higher levels of undernourishment, probably due to the vulnerability of Sub-Saharan African countries to global market fluctuations, price volatility, and supply chain disruptions. In line with our expectations, we find that GDP growth, cereal yield, and arable land are statistically significant and negatively correlated with the prevalence of undernourishment. An increase in

income and level of development is associated with a decrease in undernourishment. Higher economic resources are associated with higher levels of food security. This has been found in previous studies like Dithmer and Abdulai (2017) and Marson et al. (2023). The cereal yield coefficient is negative and statistically significant, suggesting that increased agricultural productivity can lead to greater food availability and improved food security, reducing undernourishment rates. This has been found in previous studies like Dithmer and Abdulai (2017) and Marson et al. (2023). Arable land is also negatively correlated with undernourishment, suggesting that a higher level of arable land is associated with a higher level of food security. An improvement of the agricultural sector is therefore essential for food security improvement. These findings are in line with the literature (Bonuedi et al., 2020; Marson et al., 2023; Dithmer and Abdulai, 2017). The employment coefficient is positively and significantly associated with undernourishment, indicating that higher employment levels are associated with higher undernourishment. This finding might suggest that while employment rates are increasing, the quality of jobs may be low, leading to insufficient income to combat undernourishment.

The population growth is significant and positively correlated with undernourishment. An increase in population growth is then associated with more undernourishment. Rapid population growth can strain food supply systems and increase demand pressures, making it difficult to ensure adequate food distribution and access, thereby exacerbating malnutrition. This has been found in previous studies like Dithmer and Abdulai (2017). However, we didn't find significant evidence concerning the impact of natural disasters, inflation, and political stability.

Table 2: Cereal import openness and Undernourishment

VARIABLES	2SLS-IV
Cereal import openness	3.354** (1.699)
GDP growth	-0.182*** (3.654)
Cereal yield	-0.0006** (0.0002)
Arable land	-0.526*** (0.139)
Political stability	0.913 (0.572)
Inflation	-0.020 (0.054)
Population growth	1.965** (0.974)
Employment	0.420*** (0.083)

Natural disasters	-0.053 (0.064)
Constant	-9.351 (8.677)
Country fixed effect	YES
Year fixed effect	YES
Number of countries	27
Number of observations	507
Endogeneity test	0.0264
Cragg-Donald Wald F statistic	7.365
Anderson LM statistic (p value)	0.0002
Hansen J statistic (p value)	0.907

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Robustness check

Alternative food security indicators

To make sure that our findings are robust, we repeat the analysis using alternative food security indicators, the average dietary energy supply adequacy, and the average protein supply from FAOSTAT. The average dietary energy supply adequacy represents the average availability of dietary energy in a country relative to the average dietary energy requirement of its population. It is a useful indicator for assessing food security and nutritional well-being. An increase in the average dietary energy supply adequacy indicator typically signifies an improvement in food security.

Table 3 shows the results for the average dietary energy supply adequacy as a food security indicator employing the same empirical specification as in our baseline model, the two-stage least square instrumental variable estimator. The result shows that cereal import openness affects negatively and significantly the average dietary energy supply adequacy of a country. This finding suggests that higher cereal import openness is associated with decreased dietary energy supply adequacy. This additional result confirms the finding of our baseline model on the adverse effects of cereal import openness on food security.

We also use a third food security indicator; the average protein supplies available for consumption from FAOSTAT. Protein is one of the major macronutrient groups and most of the poor countries remain close to the lower bound of the FAO-recommended daily value (Dithmer and Abdulai, 2017). An increase in protein consumption then suggests a food security improvement. Unfortunately, this indicator is only available until 2018 and doesn't cover all our period of study. However, given the relevance of this measure and the clear link with the cereal trade, we repeat the analysis using the average protein supply as a measure of

food security on a reduced sample. The results shown in Table 6 in the appendix show that cereal import openness led to a decrease in the average protein supply available for consumption. This is likely to lead to an increase in undernutrition and then improve food insecurity.

Table 3: Cereal import openness and Dietary Energy Supply Adequacy

VARIABLES	(1) 2SLS-IV
Cereal import openness	-4.290** (2.059)
GDP growth	0.210*** (0.075)
Cereal yield	0.0008*** (0.0003)
Arable land	0.596*** (0.170)
Political stability	-1.472** (0.741)
Inflation	-0.043 (0.063)
Population growth	-0.713 (1.092)
Employment	-0.397*** (0.103)
Natural disasters	0.034 (0.093)
Constant	134.393*** (10.379)
Country fixed effect	YES
Year fixed effect	YES
Number of countries	27
Number of observations	507
Endogeneity test	0.0090
Cragg-Donald Wald F statistic	7.365
Anderson LM statistic (p value)	0.0002
Hansen J statistic (p value)	0.983

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Weighted regression

In addition to our primary analysis, we also consider the impact of cereal import openness under conditions of high global food prices. To do this, we run importance

weighted (iweight) regressions using the FAO Food Price Index⁷ (FFPI) as the weight.

By assigning higher weights to observations associated with higher food prices, we estimate the trade effect primarily from years in which food prices were high. This approach provides valuable insights into the vulnerability of Sub-Saharan African countries to global market fluctuations and the associated impact on food security. Results are displayed in Table 4. These regression results suggest that during years when food prices are high, greater reliance on cereal imports exacerbates undernourishment possibly due to higher import costs or supply vulnerability. This confirms the finding of our baseline model.

Table 4: Cereal import openness and Undernourishment (Weighted regression)

VARIABLES	2SLS-IV
Cereal import openness	3.472*** (0.185)
GDP growth	-0.161*** (0.063)
Cereal yield	-0.0006***
	(0.00004)
Arable land	-0.524***
	(0.014)
Political stability	0.651*** (0.059)
Inflation	-0.011**
	(0.006)
Population growth	1.907*** (0.093)
Employment	0.402***
	(0.009)
Natural disasters	-0.042*** (0.008)
Constant	-9.386***
	(0.940)
Country fixed effect	YES
Year fixed effect	YES
Endogeneity test	0.0000
Cragg-Donald Wald F statistic	640.486
Anderson LM statistic (p value)	0.0000
Hansen J statistic (p value)	0.101

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

⁷ The FFPI is a measure of the monthly change in international prices of a basket of food commodities.

It consists of the average of five commodity group price indices weighted by the average export shares of each of the groups over 2014-2016

7. Conclusion and Policy Implications

In this study, we used panel data to analyze the impact of cereal import openness on food security (measured by the prevalence of undernourishment) in sub-Saharan Africa for the period 2000 - 2020. We employed a two-stage least square instrumental variable (2SLS-IV) estimator to deal with potential endogeneity and we controlled for country and year-fixed effects. The results showed that cereal import openness has a positive and statistically significant impact on the prevalence of undernourishment suggesting that cereal import openness increases the prevalence of undernourishment and then improves food insecurity. This finding is in line with Mary (2019), Tanaka and Hosoe (2011), Moon (2011) and Kang (2015). The negative effect of cereal import openness on food security remains significant and consistent with alternative food security indicators such as dietary energy supply adequacy as well as the average protein supply available for consumption, representing other aspects of food security.

Besides that, economic and agricultural factors have been found to affect positively food security. In fact, GDP growth, cereal yield, and arable land variables have a positive impact on food security regardless of the indicator used. On the contrary, employment in agriculture and population growth negatively affect food security.

In terms of policy implications, several recommendations can be made based on the empirical results. Our results have pointed out the adverse effect of cereal import openness on food security. A great reliance on imports then exposes countries to global market risks. Policies should aim to balance imports with increased domestic production. This could include incentives for local cereal production and reducing barriers to entry for small-scale farmers. While imports are necessary, the negative impact on food security indicates a need for careful management of trade policies. Governments should negotiate favorable trade agreements that ensure stable and affordable cereal supplies. Diversifying import sources and creating regional trade partnerships can also reduce dependency on a single market. The negative and significant relationship between cereal yield and undernourishment underlines the importance of increasing domestic agricultural productivity. Governments should invest in agricultural research and development, subsidize high-yielding and resilient crop varieties, and promote modern farming techniques. Extension services that provide training and resources for farmers can also increase productivity. Land reform policies that provide secure land tenure and access to arable land for smallholders are also essential. In addition, investment in irrigation and infrastructure can make more land suitable for farming. By enhancing domestic agricultural productivity, reducing dependency on cereal imports, and promoting economic growth, governments can address

undernourishment and help build more resilient and food-secure countries.

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9. Appendices

Table 5: First-stage regression results

VARIABLES	Dependent variable: Cereal import	
Terms of trade (log)	-0.522***	
	(0.144)	
Real exchange rate (log)	-0.440***	
	(0.129)	
GDP growth	0.007	
	(0.008)	
Cereal yield	-0.0001*** (0.00003)	
Arable land	0.061*** (0.016)	
	Political stability	-0.037
		(0.080)
Inflation	-0.015**	
		(0.006)
	Population growth	-0.090
		(0.085)
Employment	-0.035*** (0.012)	
Natural disasters	0.021** (0.011)	
Constant	8.687*** (1.752)	
Observations	507	
R-squared	0.66	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 Note: Terms of trade and real exchange rate represent the instruments

Table 6: Cereal import openness and Average Protein Supply

VARIABLES	(1)	
	2SLS-IV	
Cereal import openness	-2.127*	(1.180)
GDP growth	0.060	(0.049)
Cereal yield	0.0003	(0.0001)
Arable land		0.278**
Political stability	0.171	(0.105)
Inflation		-0.006
Population growth		(0.361)
Employment	-0.168**	-0.429
Natural disasters	0.010	(0.578)
Constant	-65.710***	
Country fixed effect	YES	
Year fixed effect	YES	
Number of countries	27	
Number of observations	476	
Endogeneity test	0.0096	
Cragg-Donald Wald F statistic	6.419	
Anderson LM statistic (p value)	0.0006	
Hansen J statistic (p value)	0.334	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7: List of Countries (27)

Benin	Madagascar
Botswana	Malawi Burkina Faso Mali Cabo Verde
Mauritius	
Cameroon	Mozambique Congo, Rep Namibia Cote d'Ivoire Niger Ethiopia Nigeria
Gabon	Rwanda
Gambia	Senegal
Ghana	South Africa
Guinea	Tanzania Guinea-Bissau Togo Kenya

Table 8: Variables and data source

Variables	Source
Prevalence of Undernourishment (%)	FAO Average protein
supply (g/capita/day)	FAO Average dietary
energy supply adequacy (%)	FAO Cereal import openness
	FAO
Inflation	World Bank WDI
GDP growth	World Bank WDI
Cereal yield	World Bank WDI
Arable land	World Bank WDI
Population growth	World Bank WDI
Employment in agriculture	World Bank WDI
Political stability and absence of violence	World Bank WGI
	Natural disasters EM-DAT
Net barter terms of trade index	World Bank WDI
Real effective exchange rate index	World Bank WDI



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