GLOBALIZATION, INNOVATION AND FOOD SECURITY IN SUB-SAHARAN AFRICA: A GMM APPROACH

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Abstract. This study aimed to determine the effect of the interaction between globalization and innovation on food security in sub-Saharan Africa over the period of 21 years, that is between 2001 to 2021. It employed secondary data which was sourced from the World Development Indicators to measure food security in terms of availability represented as "Gross Domestic Product per Capita, PPP, Dissemination (constant 2017 international $)", accessibility represented by the "Food production Index (2014-2016 = 100)", also, globalization and innovation quantified using Foreign Direct Investment (FDI) and access to mobile internet subscription (% of total population), respectively. The study used the Generalized Method of Moments (GMM) for estimation. The results of the Generalized Method of Moments analysis showed that globalization has a direct and statistically insignificant impact on food security when measured in terms of availability with a co-efficient value of 0.071 but an indirect and significant impact on accessibility with a coefficient value of -1.467. Innovation, on the other hand, was shown to have a direct and insignificant effect on availability but direct and significant impact on accessibility with coefficient values of 0.301 and 10.722, respectively. In achieving the objective of the study, the results of the GMM analysis revealed that the interaction between globalization and innovation has an indirect and significant effect on availability and a direct and significant impact on accessibility with coefficient values of -0.076 and 0.809, respectively. Based on these findings, this study recommends that a balance should be struck between globalization and innovation to improve food availability and sustainable agricultural practices should be given priority.
Keywords: *innovation, globalization, sustainable development, food security, agricultural sustainability, sub-Saharan Africa*

Introduction

The intertwined concepts of physical and economic access, coupled with the consideration of nutritional needs and personal food preferences, form the very essence of what we call food security (Okere et al., 2022; Obiakor et al., 2022). In light of the surge in global food prices back in 2007, food security has emerged as a crucial worldwide endeavor for enhancing overall well-being. The escalating interest in this subject matter is evident, as exemplified by the dedicated focus on food security through the second Sustainable Development Goal (SDG 2). This unwavering commitment signifies the global recognition of the importance of ensuring access to

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nourishment that sustains active and healthy living, reflecting our collective pursuit of a better world. According to the Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD), and World Food Program (WFP), food security entails individuals have ongoing physical, social, and economic access to adequate, safe, and nutritious food that meets their dietary requirements and personal preferences for a healthy and active life (McGuire, 2015). Ensuring the sustainability of food security entails not only the present availability of sufficient food for all individuals but also the ability to meet the food needs of future generations (Metu et al., 2016). Unfortunately, over a billion people, particularly in developing nations, such as those in sub-Saharan Africa, continue to be deprived of this fundamental human right.

The number of individuals deprived of this fundamental human right has dwindled over time. Between 2003 and 2014, the global undernourished population declined, but it began to increase in 2015. By 2017, there were approximately 1.9 billion undernourished people worldwide, with Sub-Saharan Africa and South Asia being the most affected regions (Ritchie et al., 2019). In 2019, around 690 million people, accounting for 8.9% of the global population, were undernourished, and this number is projected to reach 841.4 million (9.8% of the world population) by 2030. As of 2022, the figure for undernourished individuals stands slightly above 820 million (UNICEF, 2022; Wudil et al., 2022). Regrettably, a significant burden of this number is borne by the continent of Africa. The continent hosts approximately one-third of the global undernourished population, with a declining agriculture per capita income over the past 30 years. Despite employing about 60% of the working population, the agricultural sector in Africa contributes only 10% of export revenue and approximately 22% of GDP (Wudil et al., 2022; Obiakor et al., 2021). This poor performance can be attributed to the overdependence of African nations on food imports and the underutilization of the continent's substantial agricultural potential.

In the pursuit of food security, strategies utilizing science and technology have been proposed, recognizing the strong connection between food security and technological advancements, especially in processing and preservation (Nah and Chau, 2010; Utuk and Daniel, 2015; Juma, 2015). Africa, particularly Sub-Saharan Africa, has a significant population of chronically undernourished individuals, partially attributed to the limited capacity to process and preserve agricultural yields (Aworh, 2008). This inability to process and preserve food contributes to the heavy reliance on food imports in Sub-Saharan Africa and other sub-regions of the continent. Recent research has also shown connections between globalization, innovation, international integration, technical growth, the spread of invention, and global climate change—all of which are essential for the pursuit of food security (Aworh, 2008; Omoyele et al 2021; Sun and Zhang, 2021). The exchange of agricultural products between nations has historically played a significant role in promoting globalization (Von and Diaz-Bonilla, 2008). Globalization encompasses various socioeconomic, political, and technological activities across nations (Collier and Dollar, 2002; Umo, 2007). Economic globalization facilitates the free movement of goods, services, information, capital resources, and people, impacting multiple aspects of society, including agriculture and rural areas. The trading of food, raw materials, capital, and labor can contribute to improving food security by enhancing agricultural production, particularly in low-income nations like those in Sub-Saharan Africa (Mellor, 2003).

While scholars globally focus on food security, gaps remain in empirical studies on globalization, innovation, and food security (Mary, 2019; Fusco et al., 2020; Montolalu

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et al., 2022). Few studies explore the nexus between technological innovation and food security (Fiaz et al., 2018). No study to date examines the impact of globalization and innovation interaction on food security in Sub-Saharan Africa. This study aims to address this gap by analyzing their impact on food security in Sub-Saharan Africa.

The other parts of this work consist of the literature review, methodology, discussion and interpretation of results, and the summary, conclusion, and recommendations. The literature review entails an examination of relevant concepts, theories, and empirical studies. The methodology section describes the study area, data collection methods and sources, and the data analysis approach. Following that, the data presentation and analysis section presents the findings, interprets the results, and discusses the implications. Lastly, the summary, conclusion, and recommendations section summarize the study's key findings and presents concluding remarks along with recommendations based on the study's outcomes.

Literature review

Theoretical underpinning

Rooted in the visionary Heckscher-Ohlin (HO) international trade theory formulated by Eli Heckscher and Bertil Ohlin in the 20th century, this study draws its foundation. The HO theory proposes that nations should export goods that utilize their abundant factors of production and import goods that rely on scarce factors. In essence, a country specializes in producing and exporting goods in which it exhibits a relative efficiency compared to other nations. Pertaining to the context of food security, the HO theory advocates for countries to identify their comparative advantage in agriculture. By focusing resources and formulating trade policies that support food self-sufficiency and reduce reliance on imports, countries can promote their own food security.

Consider, for instance, a country blessed with ample land and a labor-rich population. Such a country may possess a comparative advantage in cultivating staple crops like rice or maize, thereby warranting a dedicated emphasis on expanding the agricultural sector. Conversely, a resource-scarce nation may choose to import these commodities from countries where production is more efficient. Embracing foreign trade in agriculture and related products thus becomes a pivotal element in advancing food security, particularly in the African context. The significance of the HO theory in this study lies in its alignment with the unique agricultural resources endowed by each country under examination. By harnessing and exporting their abundant resources, these countries can enhance their prospects for achieving food security. Therefore, this study proposes to test the null hypothesis that:

H_0: Globalization and innovation interaction has no significant impact on food security in sub-Saharan Africa.

Empirical review

Due to the absence of domestically produced commodities, desert regions like Saudi Arabia are projected to rely heavily on imports, placing food security as a paramount concern for policymakers. By 2050, it is projected that Saudi Arabia will rely entirely on imported goods to fulfill its domestic requirements. In their study, Dutta et al. (2017) focused on addressing Saudi Arabia's food security challenge through innovation. The research identified several technologies with the potential to enhance local output and

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meet the country's food security needs. The study highlighted advancements such as hydroponics and greenhouse farming, saltwater collection, support and funding for bio-salinity research, and rainwater harvesting. These technological breakthroughs were deemed essential for expanding national food production in Saudi Arabia and ensuring improved food security. The article concluded by emphasizing the significant gap between agricultural demand and supply, which necessitates the implementation of both conventional and cutting-edge technologies. These include land and water conservation, greenhouse farming, saltwater harvesting, and the adoption of hydroponics and aquaponics.

In a study conducted by Wuletaw (2018), the complex interaction between agricultural production and population dynamics in Ethiopia was examined. The research aimed to analyze population growth trends and explore the relationship between population and food production in the geographical context of Ethiopia. The study revealed that both population growth and agricultural production have been increasing over the years. However, the paper highlighted that agricultural production growth exhibited fluctuations, unlike the consistent rise in population. The increase in population can be managed effectively if it is supported by well-designed agricultural policies and strategies. With the implementation of comprehensive and feasible agricultural policies, the growing population can have access to an ample supply of agricultural products for both domestic consumption and sale. Addressing land-use stress necessitates the adoption of effective population policies, improved land-resource management, and coordinated efforts. Thus, based on the assessment, Wuletaw suggested that strengthening agricultural policy and implementing innovative agricultural methods are among the most viable approaches to address the challenges posed by population growth.

In their study, Fusco et al. (2020) examined the impact of trade liberalization on food security within the European Union (EU). The research corroborated previous findings that indicated a growing prevalence of food insecurity even in affluent countries. In Europe, discussions on food security have expanded beyond the availability, nutritional value, and quality of food, highlighting the importance of trade policies that ensure sufficient food security. To investigate the relationship between trade openness and food security across European nations, the study employed a dynamic panel analysis using the generalized method of moments (GMM). Two food security measures, namely average protein supply and average dietary energy supply adequacy, were utilized to capture both the quantity and nutritional quality of food availability. To enhance the reliability of the empirical data, the research conducted three separate regressions, each employing a different trade openness variable (trade openness, tariff, globalization). The findings of the analysis demonstrated that openness to commercial activity had a statistically significant and overall beneficial impact on the food security of European nations.

Enilolobo et al. (2022) conducted a study to investigate the determinants of food security in Nigeria. The research employed a multiple regression model that considered the influence of various factors, including agricultural employment as a measure of labour input, gross fixed capital as an indicator of domestic capital investment, bank lending to agriculture as a measure of bank inclusion, the ratio of carbon dioxide emissions to GDP as a measure of environmental quality, and oil revenue. The autoregressive distributed lag (ARDL) technique was used for the model analysis, and pairwise granger causality was employed to ensure the robustness of the findings. The

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study revealed that only domestic capital had a positive impact on food security in Nigeria, while bank loans had a positive impact only in the short term. These results led to recommendations for improving the bank lending policies of the Central Bank of Nigeria (CBN) in support of the agricultural sector. The study also suggested that the Federal Ministry of Agriculture, the Ministry of Finance, and the private sector collaborate to develop both short- and long-term strategies for the growth of Nigeria's agricultural sector.

Montolalu et al. (2022) conducted a study to analyze the effects of trade liberalization and dietary consumption on food security in various districts of Indonesia. The research focused on Indonesia as a case study to investigate the relationship between trade liberalization, measured by food import tariff exposure, and food security, assessed through nutritional intake. A panel dataset comprising information from 496 districts in Indonesia was utilized, and fixed-effect regression analysis was employed to examine the connection between international trade and food security. The findings indicated a negative correlation between import tariff exposure and dietary consumption, with variations observed across different economic sectors. The research also revealed that the industry sector faced higher tariffs on calorie and protein consumption compared to the agriculture sector. Furthermore, the study highlighted the disparities in agricultural and food-manufacturing import taxes across different islands in Indonesia. In conclusion, the research proposed considering geographic location, economic conditions, and employment distribution within each district when implementing tariff controls and other trade liberalization programs.

Liu et al. (2022) conducted a study titled "Globalization and Economic Growth: A Sustainability Analysis for South Asia Countries." The study addressed the ongoing empirical interest and significance of globalization's impact on national economies, as well as the remarkable economic growth experienced by certain countries in South Asia as a result of globalization. The authors aimed to contribute to this field by examining the long-term and moderating effects of economic globalization on various direct factors influencing economic growth. The research focused on eight South Asian countries over a 24-year period from 1996 to 2019. The study made use of data on globalization obtained from the Konjunkturforschungsstelle Globalization index, World Governance Indicators, and the international country risk database. The analysis employed a pooled autoregressive-distributed lag (ARDL) approach. The findings revealed that while globalization had a positive impact on economic development, the effect could be counteracted by increasing interest and inflation rates. The study suggested that leveraging economic globalization to promote investment and combat corruption could lead to sustained long-term development in South Asian countries, as indicated by the adjusted estimates.

Mok et al. (2020) conducted a study focusing on innovative and technologically advanced approaches to address the growing concern of food security worldwide, caused by factors such as urbanization and industrialization. The study specifically looked at Singapore as a city-state striving to enhance its food self-sufficiency through the implementation of technology. Due to its limited size and scarcity of natural resources, Singapore has heavily relied on technological advancements to secure its food supply, serving as a potential guide for other nations facing similar constraints. The study highlighted the advantages of these techniques while also acknowledging the challenges that need to be addressed before broader implementation can occur. Singapore has utilized technologies such as vertical farming, aquaponics in urban

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farming, nutrient recovery from food waste, biodegradable food packaging from durian rinds, natural preservatives, insect farming, microalgae, and cultured meat as alternative protein sources. Many other countries could adopt these technologies to overcome geographical and resource limitations similar to Singapore. However, several obstacles need to be overcome, including the slow pace of innovation in farming, processing, and alternative food sources, cost analysis, and methods to increase yield, among others.

In their contribution towards achieving the United Nations Sustainable Development Goals by 2030, particularly Goal 2 of ending hunger, achieving sustainable food security, improving nutrition, and promoting agriculture, Anser et al. (2021) conducted a study focusing on the impact of social inclusion and innovation on food security in the West African sub-region. Utilizing panel data covering 15 West African nations over a span of 19 years, the researchers employed the Generalized Method of Moments (GMM) for analysis (2005-2018). The findings from the System GMM analysis indicated that the adoption of new technologies and the expansion of social networks play a significant role in enhancing food security. The research demonstrated that an increase in social inclusion and innovation levels in West Africa could potentially lead to a 41.5% improvement in food security through social inclusion and a 13.6% improvement through innovation. Based on these results, the study's authors concluded that fostering greater social participation is crucial to safeguard agricultural households from risks, vulnerabilities, and socioeconomic shocks, thereby enabling Africa to adequately nourish its growing population. The study emphasizes the importance of strengthening agricultural innovation to enhance production and achieve long-term food security goals in the region (Anser et al., 2021). By promoting social inclusion and embracing innovative approaches, West Africa can make significant strides towards ensuring food security and achieving the United Nations SDGs.

Methodology

Sample and data

This study examined sub-Saharan Africa's food security over a span of 21 years, from 2001 to 2021, using a panel dataset of 38 countries. The data, sourced from the World Development Indicators (WDI) by the World Bank, encompassed key variables such as food availability, food accessibility, population growth rate, arable land, globalization, and innovation. The selection of years and countries was based on the availability of comprehensive data for a thorough analysis. This study aimed to provide a comprehensive view of the region's food security landscape and understand the factors influencing it.

Estimation procedure

This study aimed to investigate the impact of the interaction between globalization and innovation on food security, specifically focusing on food availability and food accessibility. The research involved conducting a descriptive statistics analysis to understand the characteristics of the datasets. Additionally, tests were performed to determine the stationarity properties of the variables. Finally, in order to achieve the study's objective and address the research question, a Generalized Method of Moments analysis was employed to estimate the models. All these tests were carried out using the EViews version 10 software.

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Model selection

To analyze the study's objective, the model specification was formulated by drawing upon the theoretical framework and relevant empirical studies. Thus, considering the theoretical framework and study objectives, following Aderemi et al. (2020) and Opele et al. (2022), the model can be expressed as follows:

$$FSi = f(IN,GL,GL*IN,X) \quad \text{(Eq.1)}$$

where: FSi = food security dimensions to be used in this study.

In this study, the estimation of the model revolves around measuring food security, with a focus on food availability and accessibility. The consumption of food plays a crucial role in mitigating food insecurity, and it is primarily determined by the level of food availability and accessibility (Montolalu et al., 2022). Therefore, the representation of food security in this study can be defined as follows:

1 = (Availability (AV)) proxied by "Food production Index (2006 = 100)"

2 = (Accessibility (AC)) proxied by "Gross domestic product per capita, PPP, Dissemination (constant 2011 international $)"

IN = Innovation proxied by access to mobile internet subscription (% of total population)

GL = Globalization proxied by foreign direct investment

GL × IN = Interaction between globalization and innovation (derived by multiplying the proxy for both variables)

X = Control variables that may affect food security

Hence, from *Equation 1:*

$$AV = \beta 0it + \beta 1INit + \beta 2GLit + \beta 3GL*INit + \beta 4Xit + \mu it \quad \text{(Eq.2)}$$

$$AC = \alpha 0it + \alpha 1INit + \alpha 2GLit + \alpha 3GL*INit + \alpha 4Xit + \mu it \quad \text{(Eq.3)}$$

In this study, several control variables (X) have been chosen to account for their potential influence on food security. The first control variable is population growth, which is selected based on its commonly assumed negative impact on food security. Various empirical studies, including Prosekov and Ivanova (2018), Oguntegbe et al. (2018), Fusco et al. (2020), and Pickson and Boateng (2022), have highlighted the significance of population as a crucial factor in the discourse on food security. The second control variable is arable land, chosen due to its fundamental role in food production. It is widely recognized that food security cannot be adequately addressed without considering the availability of arable land. Studies such as Metu et al. (2016), Oguntegbe et al. (2018), and Prosekov and Ivanova (2018) have also emphasized the importance of arable land as a determinant of food security. Therefore, *Equations 2* and *3* can be expanded further as Equations 4 and 5 below:

$$AV = \beta 0it + \beta 1INit + \beta 2\ GLit + \beta 3GL*INit + (\beta 4PGit + \beta 5AL) + \mu it \quad \text{(Eq.4)}$$

$$AC = \alpha 0it + \alpha 1INit + \alpha 2GLit + \alpha 3GL*INit + (\alpha 4PGit + \alpha 5AL) + \mu it \quad \text{(Eq.5)}$$

where: PG = Population growth, AL = Arable Land, β0 and α0 are the intercept of the models, β1 and α1 to β5 and α5 = Parameter Estimates, μ = Stochastic Disturbance Error Term, i = country (38), t = time.

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Therefore, *Equations 4* and *5* will be specified to form the GMM models as follows:

$$\ln AV = \beta 0it + \Omega InAVit{-}1 + \beta 1 \ln GL{*}IN it + \beta 2 \ln PG it + \beta 3 \ln AL + \mu it \quad \text{(Eq.6)}$$

$$\ln AC = \alpha 0it + \partial InACit{-}1 + \alpha 1 \ln GL{*}IN it + \alpha 2 \ln PG it + \alpha 3 \ln AL + \mu it \quad \text{(Eq.7)}$$

Ω, and ∂ are the coefficient of the first-lag of the dependent variables in *Equations 5* and *6* respectively.

Results

Descriptive analysis

The descriptive statistics report provides an overview of six variables: AC, AL, AV, GL, IN, and PG. For the variable AC, both the mean (4217.614) and the maximum value (23681.58) suggest the presence of large values in the dataset. The standard deviation (4522.466) indicates a wide range of values for AC. In the case of AL, the mean (14.82244) is relatively low, and the standard deviation (13.14372) indicates moderate variability. AV exhibits a slightly peaked and heavier-tailed distribution, as indicated by the negative skewness (-0.322) and the kurtosis (3.406) values. GL shows a heavily tailed and positively skewed distribution, as evidenced by the high kurtosis value (62.748). Similarly, IN displays a peaked and heavier-tailed distribution, as indicated by its high kurtosis value (13.04508). Lastly, the PG distribution is slightly skewed to the left, with a negative skewness value, and has a kurtosis value of 3.602.

	AC	AL	AV	GL	IN	PG
Mean	4217.614	14.822	91.012	4.403	3.344	2.396
Median	2252.675	10.669	95.985	2.668	0.893	2.614
Maximum	23681.58	48.722	181.510	103.337	36.884	5.785
Minimum	687.194	0.321	30.860	-10.954	0.000	-0.401
Std. Dev.	4522.466	13.143	20.859	8.034	6.850	0.946
Skewness	2.170	1.173	-0.322	6.490	3.239	-0.701
Kurtosis	7.255	3.243	3.406	62.748	13.045	3.602
Jarque-Bera	1228.520	185.099	19.298	124300.4	4744.571	77.319
Probability	0.000	0.000	0.000	0.000	0.000	0.000
Observations	798	798	798	798	797	798

Unit root test

A variable is said to be non-stationary if certain characteristics of the data points change over time while if the characteristics of the data points of the variable remain constant over time, it is stationary. Based on the ADF test results, it is observed that AV, AC, and IN are classified as I(1) variables, indicating that they are non-stationary in their levels and necessitate differencing for achieving stationarity. Conversely, AL,

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GL, PG, and GL*IN are classified as I(0) variables, signifying that they are stationary in their levels and do not require differencing for achieving stationarity. The outcome of the unit root test emphasizes the presence of both stationary and non-stationary variables within the analysis. This information is crucial for selecting an appropriate econometric model that accounts for the differing stationarity properties of the variables.

Variable	ADF		Order of Integration
	Level	1st difference	
AV	NA	620.213* (0.0000)	I(1)
AC	NA	325.979* (0.0000)	I(1)
AL	413.889* (0.0000)	NA	I(0)
GL	196.867* (0.0000)	NA	I(0)
IN	NA	228.752* (0.0000)	I(1)
PG	117.580* (0.0016)	NA	I(0)
GL*IN	203.214* (0.0000)	NA	I(0)

Model estimation

The presented table below displays the outcomes of a thorough regression analysis involving two dependent variables: food availability represented as “AV” and food accessibility represented as “AC.” This analysis comprises a range of independent variables, including the lagged values of the dependent variables shown as y(-1) through y(-4), and independent variables AL, GL, GLIN, IN, and PG. The findings underscore a noteworthy connection between the independent and dependent variables. The nature of this relationship however varies depending on the specific independent and dependent variables under consideration. The regression findings reveal that, with the exception of GL and IN, all independent variables bear statistically significant impact on the dependent variable AV (equation 5). Furthermore, y(-1), AL, IN, and GL demonstrate a positive correlation with the dependent variable AV, whereas GL*IN and PG show a negative correlation. As for the dependent variable AC (equation 6) variable, all independent variables exhibit statistically meaningful relationships. The outcomes indicate that the fourth lag of AC depicted as y(-4), AL, and GL display negative connections with the dependent variable AC, whereas y(-1), y(-2), y(-3), GL*IN, PG, and IN showcase positive associations. The statistical importance of the independent variables is assessed through the Wald chi-square test, where a p-value of 0.05 or lower signifies that the model is statistically significant. Additionally, the J-statistics suggest that the instruments utilized in the analysis maintain their validity.

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Independent variables	Equation 5	Equation 6
	Dependent variable: AV	Dependent variable: AC
y (-1)	0.8406* (0.000)	0.858* (0.000)
y (-2)	NA	0.066* (0.000)
y (-3)	NA	0.080* (0.000)
y (-4)	NA	-0.146* (0.000)
GL*IN	-0.076* (0.000)	0.809* (0.000)
AL	1.972* (0.000)	-5.667* (0.000)
GL	0.071 (0.947)	-1.467* (0.000)
IN	0.301 (0.445)	10.722* (0.009)
PG	-3.035 * (0.000)	1.941 (0.644)
No. of observations	720	606
No. of groups	38	38
Wald chi^2	14207.87* (0.000)	3275305. * (0.000)
AR(1)	-3.768* (0.000)	NA NA
AR(2)	-1.401 (0.161)	-0.003 (0.997)
J-statistics	36.841 (0.255)	33.747 (0.336)

y(-1), y(-2), y(-3) and y(-4) show the lag of AV and AC
* represents significance at 5% levels of significance. Values in parenthesis are P-values

Discussion

Descriptive analysis

The descriptive statistics reveal several characteristics of the variables. Variable AC exhibits a significant spread of values, as indicated by its high mean and maximum value. The large standard deviation, positive skewness, and kurtosis suggest that the data has a right-skewed distribution with a heavy tail, implying the presence of some extreme values. On the other hand, variable AL exhibits a narrow range of values. Its positively skewed distribution and slightly leptokurtic nature suggest that while the data is concentrated around the mean, there are a few instances of higher values. Variable AV's relatively high mean and maximum value of variable AV imply a wider range of values. Negative skewness and a slightly peaked, heavy-tailed distribution indicate that while most values cluster to the left, there are instances of higher values that spread out more to the right. Variable GL has a low mean but an extremely high maximum value, with positive skewness and an extremely leptokurtic distribution. Variable IN has a low mean but displays a wide dispersion, evident from its high standard deviation. Positive

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skewness and a highly peaked, heavy-tailed distribution suggest that the data is concentrated around the mean but also has some larger values. Lastly, characterized by a low mean, negative skewness, and slightly peaked, heavy-tailed distribution, variable PG has values that are mainly concentrated to the right of the mean. The negative skewness indicates that there are a few lower values that are more spread out. It's important to note that none of the variables exhibit a normal distribution, as confirmed by the failure of the Jarque-Bera test for normality. This suggests that the data distributions deviate from the symmetrical and bell-shaped pattern typically associated with a normal distribution. Instead, these variables display various degrees of skewness and kurtosis, indicating differing patterns of data distribution and potential presence of outliers or extreme values.

Model estimation

The findings of the estimated models indicate that the interaction between globalization and innovation is found to have a significant impact on both food availability and accessibility. However, its effect on food security proxy for availability is negative, indicating that an increase in the interaction between innovation and globalization may decrease food security proxy for availability. On the other hand, food security proxy for accessibility will increase due to the direct effect of the interaction between globalization and innovation. Regarding innovation, the results reveal a positive but insignificant effect on food security proxy for availability in sub-Saharan Africa contrary to the study of Anser et al. (2021). However, innovation has a significant and positive impact on food security proxy for accessibility, aligning with the findings of Anser et al. (2021). This implies that an increase in innovation in sub-Saharan Africa can significantly improve food accessibility. Furthermore, the relationship between globalization and food security in sub-Saharan Africa varies depending on the specific aspect of food security being examined. When measuring food availability, globalization shows a positive impact, but this effect is not statistically significant, consistent with the findings of Fusco et al. (2020) but in contrast to the study of Anser et al. (2021). Conversely, in terms of food accessibility, globalization has a negative and insignificant effect. Specifically, the proxy for globalization, foreign direct investment (FDI), demonstrates a negative and insignificant impact on food security in terms of accessibility in sub-Saharan Africa.

In addressing the objective of the study, the results suggest that the interaction between globalization and innovation has a negative impact that is statistically significant on food security proxy for availability in sub-Saharan Africa. This implies that as global integration and innovation interact increasingly, food availability and food production experiences a fall. This is understandable as an increase in global integration and innovation together could increase emigration from sub-Saharan African countries to developed countries and also discourage farming and increase desire for more technologically oriented work thereby causing a fall in agricultural activities and food production. Conversely, when considering food security proxy for accessibility, the interaction between globalization and innovation is seen to have a positive and significant impact in sub-Saharan Africa. The interaction of globalization and innovation can improve the earnings of nations thereby giving them the economic access to purchase food. Beyond this, the increase in innovation with globalization also improves the geographical access of sub-Saharan Africa member countries. These findings contribute to addressing the objective of the study.

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Conclusion and recommendations

This research analyzed the impact of the interaction between globalization and innovation on food security in sub-Saharan Africa spanning the period of 21 years from 2001 to 2021. The sample was made up of 38 countries in sub-Saharan Africa that were selected using the convenient sampling method. According to the result of the model analyzed, the study reaches a conclusion that the interaction between globalization and innovation has a significant and indirect impact with food security in sub-Saharan Africa when measured as availability but has a significant and direct impact on food security when measured as accessibility in sub-Saharan Africa. Based on the findings of the study which showed the significant and indirect impact of the interaction between globalization and innovation on food security measured as availability, it is important to strike a balance between embracing global integration, embracing technological advancement and promoting local agricultural practices. Policies and initiatives should be designed to leverage the benefits of globalization while ensuring the preservation and enhancement of domestic food production. Also, recognizing the direct impact of the interaction between globalization and innovation on food security measured as accessibility, there is a need to prioritize sustainable agricultural practices that enhance productivity and improve the availability and affordability of nutritious food. This can be achieved through investment in research and development, capacity building, and the adoption of environmentally friendly farming techniques.

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