



## Article

# The Implications of Food Security on Sustainability: Do Trade Facilitation, Population Growth, and Institutional Quality Make or Mar the Target for SSA?

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**Abstract:** This study examines the impactful role played by trade facilitation (TF) in promoting or hindering food security in a panel of 34 sub-Saharan countries for the period 2005–2019. The empirical evidence is based on the Two-Step Dynamic System Generalized Method of Moments estimator, employed to account for econometric concerns bothering on unobserved heterogeneity and potential endogeneity inherent in the variables used. The empirical findings show that the nature of TF procedures, which are inefficient, negatively impact food security in SSA. These effects are evident on the availability and accessibility dimensions of food security as well as their composite index. While it is noted that this result runs counter to the established a priori of positive signs on the one hand, it however portrays the reality of the economic phenomenon in SSA on the other/hand. In balance, the present TF regime can best be described as anti-food security as suggested by the prevailing burdensome procedures involved in exporting and importing staple food items. The functional roles of population growth and institutional quality are empirically enhanced divergently. Going forward, we recommend that for food sufficiency and Sustainable Development Goals to be achieved quickly, governments within the region would need to finetune the underlying modalities of the present TF regime

**Keywords:** trade facilitation; food security; generalized method of moments; Africa



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## 1. Introduction

The prevalent issue of food insecurity has persisted in the last three decades or more despite substantial progress documented in global agricultural sectors. Ironically, the right to feed and be free from hunger and malnutrition remains an internationally recognized human right (Gutterman, [1]). For instance, the universal right to food was first identified in the Universal Declaration of Human Rights in 1948; this was explicitly codified in Article 11 of the International Covenant on Economic, Social and Cultural Rights (ICESCR). Similarly, in 1974, the United Nations stated that “every man, woman and child have the inalienable right to be free from hunger and malnutrition to develop fully and maintain their physical and mental faculties” (Office of the United Nations High Commissioner for Human Rights, [2]). Not only that, food and other food security-related issues remain one of the cardinal objectives of Sustainable Development Goals (hereafter, SDG) (Ibrahim et al. [3]). In more specific terms, the second SDG agenda calls for improved nutrition and an end to hunger by the year 2030, and within the genre of the goals are targets 2.1 and 2.2 that stress access to safe, nutritious, and sufficient food for all, as well as the need to eliminate all forms of malnutrition. It is also important to state that the same issue forms an

essential agenda in the Group of Twenty's (G-20) sustainable development plan. What is more, the United Nations (UN) placed high priority on achieving the SDG-2 by setting up an ad-hoc focused on delivering the target on food security with corroborating efforts from the World Trade Organization (WTO) on agriculture. Despite all these recognitions, the available statistics continue to point to a rise in world hunger, with an estimated 821 million undernourished people—approximately one out of every nine people in the world.

While the incidence of food security and undernourishment appears to be stable in most regions of the world, including Asia, this situation seems to be increasing in almost all regions of Africa and South America. Most unfortunately, the African continent has the largest prevalence of undernourishment (PoU), affecting almost 21% of the population (more than 256 million people; see FAO, IFAD, UNICEF, WFP, and WHO, 2018 for further exposition). On a similar count, an alternative metric for food security of the same report still shows one-quarter of over 50 million children under five, in the same continent, to have been affected by wasting.

However, a greater concern is that Africa's continent has been off-track in meeting SDG 2 (see, FAO, [4] for details). The likely reason that may inform such a remark about the continent may have been based on her food self-insufficiency posture occasioned by conditions such as global economic conditions, weak commodity prices, population growth, droughts, and conflicts, to mention but a few (Makwata, [5]). Thus, the imperative of closing the food deficits may suggest that the food-deficit countries would trade with food surplus economies via food importation in order to augment inadequate domestic production. FAO [6] reports also alluded to the fact that, of the regions in the world, sub-Saharan Africa's net imports have been growing, primarily because of population growth. However, trade-related barriers have been alleged as constituting a major impediment to food security in the region.

What is more, even the continent's complex agricultural supply chains are challenged by intricate and burdensome import and export procedures (Kareem et al., [7]). Available statistics reveal the customs clearances are often involved in long delays, even for perishable goods that require minimum clearance times (Kuteyi, & Winkler, [8]; Safaeimanesh, S., & Jenkins, [9]). Instances abound, in Kenya, permits to legally import grains are available only in Nairobi (Nyameino, Kagira and Njuki [10]). Also, traders desirous of exporting food staples from Northern Mozambique to Southern Malawi are required to obtain an export permit from Quelimane on the central coast of Mozambique (Tschirley, Abdula and Weber, [11]). The situation in Tanzania is another case in point where all certificates and permits to import grain legally can be obtained only in person in Dar es Salaam. These are just a few instances out of the many. The pertinent concern is: what do trade facilitation procedures portend for food security in sub-Saharan Africa (SSA)? (sub-Saharan Africa (SSA) and Africa are used interchangeably in this study).

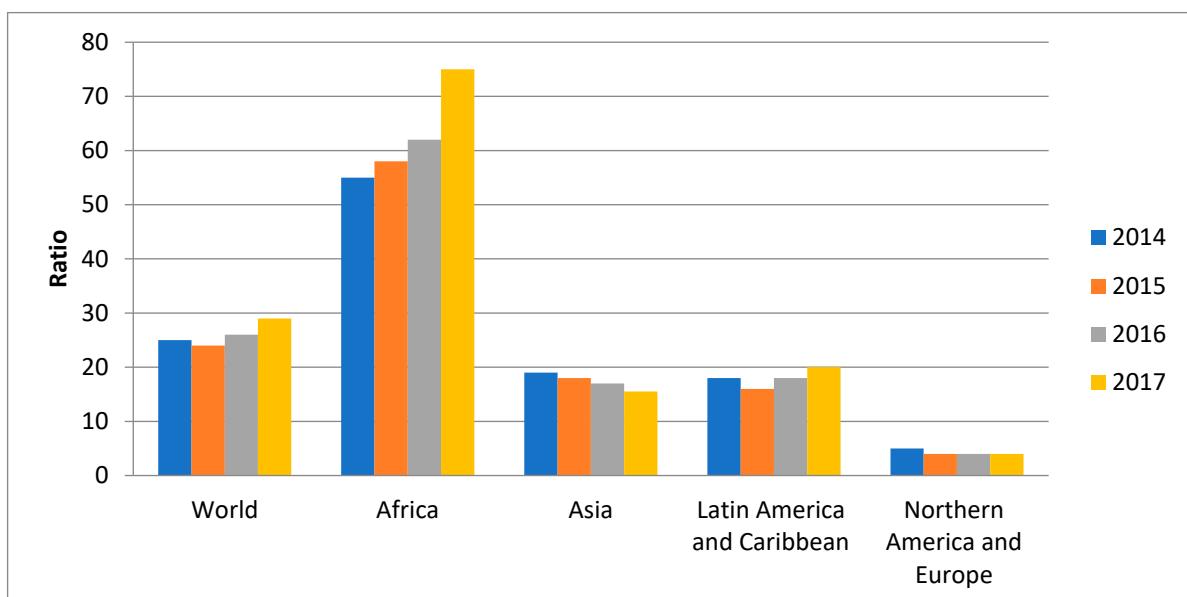
The study extends the frontier of knowledge and contributes to extant literature in the following ways. First, it is doubtless that a huge body of studies exists on the drivers of food insecurity, mostly for the developing economies. Such studies include but are not limited to those who have examined food security in relation to: poverty level (Molini, [12]; Kuku et al., [13]; Mahadevan and Suardi, [14]; Mahadevan and Hoang, [15]), population growth (Brown [16]; Masters et al., [17]; Tian et al., [18]), climate change (Rasul and Sharma, [19]; Dawson et al., [20]), loss of arable land (Liu et al., [21]; McMichael et al., [22]), food prices (Koizumi [20]; Campbell et al., [23]), unemployment (Loopstra and Tarasuk [24]; Etana and Tolossa, [25]), credit to agriculture (Hussain and Thapa, [26]), and trade and trade liberalization (Dithmer and Addulai, [27]), among others. More recently, biofuels production has equally been linked to it (see, Subramaniam, Masron and Azman, [28]), as well as energy (Taghizadeh-Hesary et al., [29]), the Paris agreement on climate change (Doelman et al., [30]), the business model (Danse et al., [31]), governance quality and remittances (Ogunniyi et al., [32]), and certification sustainability (Schleifer and Sun, [33]). More worrisome, however, is that most of these studies have largely concentrated on demand-side arguments rather than the supply-side constraints. This is troubling as we can

hardly talk about demand if supply is non-existent. This present inquiry is important by relating food security to trade facilitation (hereafter, TF), because without it, trade becomes rather ineffectual. Second, a broader perspective of food security is used rather than a specific dimension of food security that previously related studies have used. Similarly, various surrogates of TF will be used both separately and aggregately. Taking such a broader lens will enable a more specific tailor-made policy stance to be undertaken rather than just basing the study's conclusion on unsubstantiated claims or hunches. Third, to the best of our knowledge, this is the first empirical attempt at conducting a detailed quantitative study for a region like SSA that has been plagued by food security problems coupled with inefficient trade facilitation procedures as compared to other regions. What is more, major commodities in SSA are in net import status and this has been argued to intensify over the next decade (see, FAO, [4]). Lastly, the consideration of the novel system generalized method of moments is worthy of lauding as it accounts for the econometrical problems, including reverse causality, simultaneity bias, and endogeneity concerns that are often inherent in macroeconomic data.

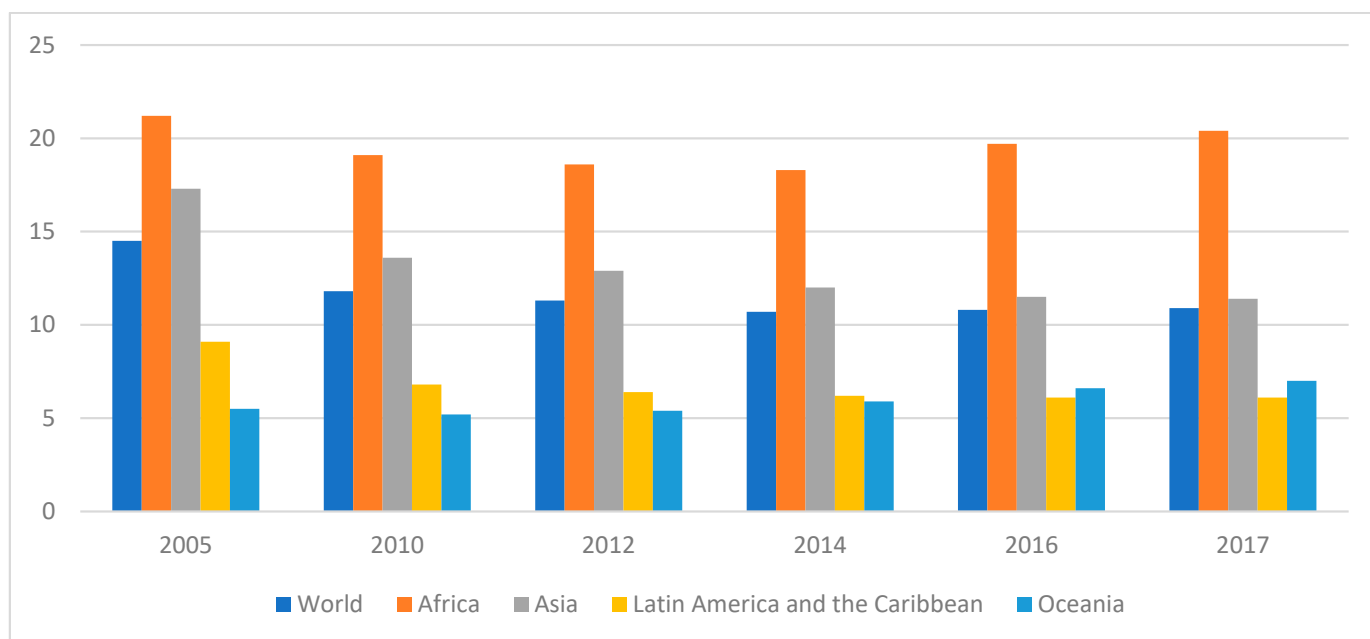
#### *Stylized Facts on Trade Facilitation and Food Security*

This section showcases factual background information about trade facilitation and food security across the regions, and within the sub-Saharan region, to enable us to put the discussion on the relationship in proper perspectives.

Food security has become a global concern, but specifically, its impact has been found to be more profound among the countries in the developing world. From Figure 1 below, it can be observed that food security in the African continent is characterized by a higher severity of food insecurity than other continents. In fact, the continent has taken a lead in all the years by exhibiting another trait of severity of food insecurity by surpassing the world average in more than two folds. Another conspicuous feature of the continent's food insecurity is that it maintains a consistent upward trend throughout the years. The food insecurity in the Northern America and Europe regions is quite negligible, as observed from the diagram. This is equally supported by the severity of undernourishment in Figure 2. Overall, Africa exhibits a significant lead in the incidence of food insecurity compared to other regions.



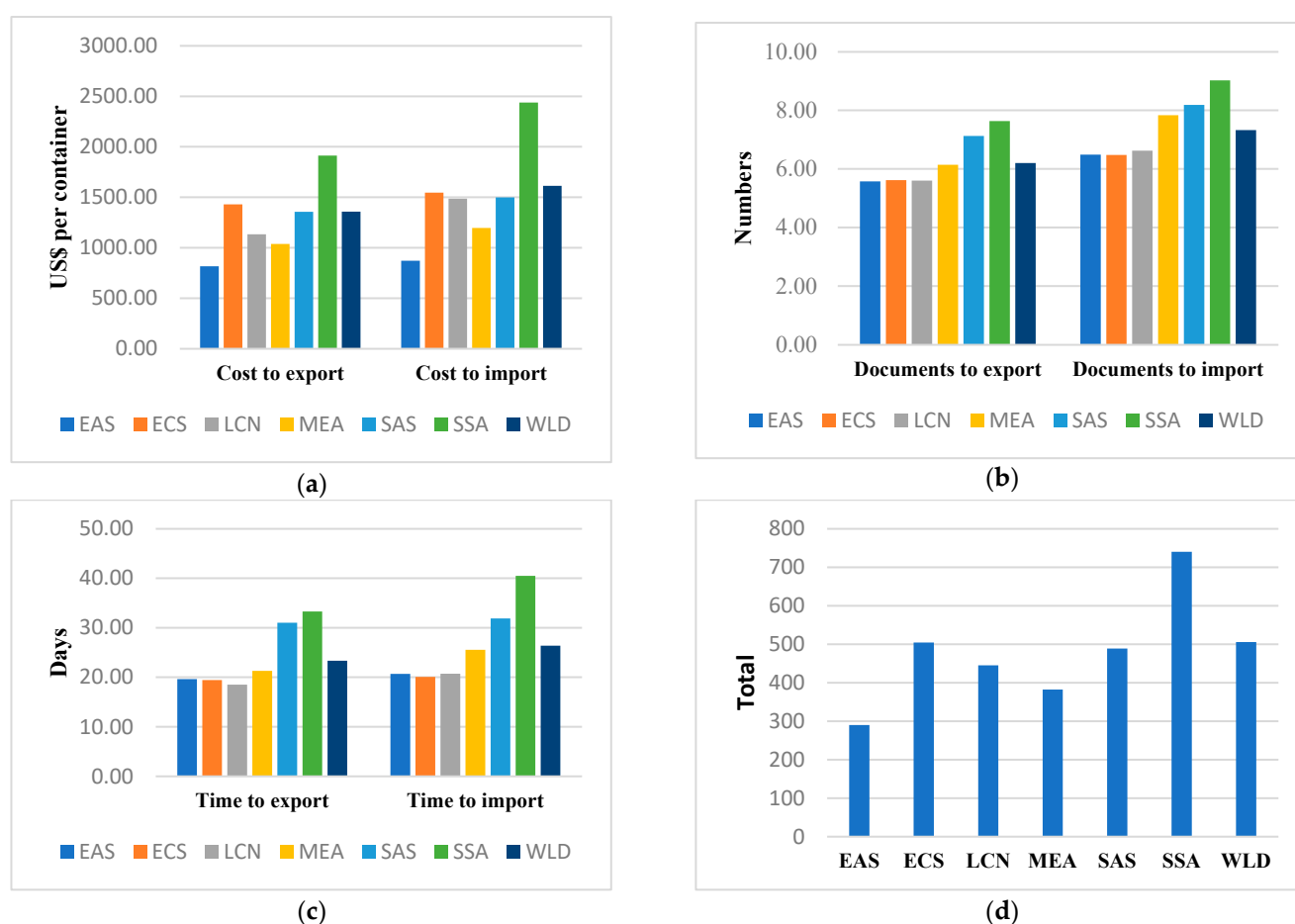
**Figure 1.** Severe food insecurity across the region. Source: FAO, 2019.



**Figure 2.** Number of undernourished people across the regions. Source: FAO, 2019.

Figure 3a–d present apt analyses on the state of art regarding the measures employed in the ease of trade for SSA. As revealed in the schema, it can be seen that the sub-Saharan African (SSA) region is far behind other regions in terms of procedures relating to trade, particularly with respect to costs, documents, and time to import and export. SSA constitutes the most expensive trading environments (see Figure 3a–c), and the aggregate trading costs in Figure 3d further accentuate the individual indicators.

The most pathetic concern that can be gleaned from the graphs is that the mean values for economies in SSA surpassed the global averages. Precisely, about 1913 USD (2437.7 USD) is required to export (import) in SSA whereas 817 USD (871 USD) is observed to be needed in East Asia and the Pacific. Besides, the costs amounting to 1500 USD are required to export (import) in other regions and the world at large. All these indicators portray a situation of inefficiency in the SSA region and noticeably, this seems to trickle down to all the countries within the region. Arguably, this situation may be held accountable as responsible for the prevalence of food insecurity in the region through their hindering effects on agriculture exports. For instance, despite the fact that Burkina Faso has been a long-time member of WTO since 1995, agricultural exports into the country are still faced with higher barriers of nearly 14.6% which is higher than non-agricultural exports of 11.5% (Ibrahim et al., [34]). It is higher in Burundi with 19.8% and 11.7% barriers for exporting agricultural and non-agricultural products into the country. As a corollary, over 99% of all imports (both agricultural and non-agricultural) into Singapore are duty-free and the country remains one of the most liberal countries in the world (Ibrahim et al., [35]).



**Figure 3.** (a) Cost to Trade. (b) Documents to Trade. (c) Time to Trade. (d) Trade Cost. East Asia & Pacific (EAS); Europe & Central Asia (ECS); Latin America & Caribbean (LCN); Middle East & North Africa (MEA); South Asia (SAS); Sub-Saharan Africa (SSA); World (WLD). Source: WDI (2019).

The rendition of the analyses provided above suggests a plausible pre-empirical conclusion on three key points. First, the SSA region is not secured food-wise. What is currently in vogue is the prevalence of food insecurity and undernourishment, which are high in the region and surpass those of other regions. Second, trade facilitation procedures are found to be grossly inefficient, stringent, and cumbersome in SSA rather than in other regions. Third, the prevalence of inefficient TF procedures has been attributed as major bottlenecks to the import of agriculture into SSA. Based on the foregoing, it can be hypothetically inferred that inefficient trade facilitation seems to be a hindering factor to food security in SSA. However, caution must be exercised as this assertion has not been subjected to rigorous empirical analysis vis-à-vis withstanding the established theoretical postulations. In light of the foregoing, the core of subsequent sub-sections addresses the concerns.

## 2. Literature Review

The concept of food security and its related areas have been massively researched in the literature. This is not surprising since the concept of food and other food items remain the core of basic human needs. A searchlight into the concept reveals the extant literature has been motivated by varying factors that determine how well a nation, community, households, and individuals are food secure or insecure. For instance, Ibrahim et al. [34] examine the extent to which trade facilitation drives agricultural sector performance in SSA from 2005 to 2019. The study relies on the SYSGMM estimator and reveals that trade facilitation on imports drives agricultural sector performance whereas export procedures

hindered it. Jiahao et al. [36] evaluate the extent to which trade facilitation and institutions drive sustainable economic growth in SSA based on the system GMM from 2005 to 2019. Findings reveal that the role of trade facilitation in achieving SDGs-8 bothering on sustainable economic growth is not negligible. Besides, the various proxies of institutions provide varying effects in the region. Kareem et al. [7] probe the consequences of non-adherence to trading procedures in Africa's food exports, which have contributed to the increased incidence of food insecurity in the continent. Outcomes of the study uncover that inefficient trade procedures and inconsistent food logistics contribute to the poor performance of the continent in meeting the food demand, both from imports and exports angles.

Raheem et al. [37] appraise how cereal grains contribute to food security and its sustenance in Africa through selected countries comprising Uganda, Nigeria, Namibia, and Ghana. The study submits that Africa is a net importer of food, notwithstanding her richness in agriculture. Amidst the growing cases of food insecurity, the study finds the production of cereal grains and other crops as a saving grace and the most appropriate path to achieving sustainable food security in the continent. Grote et al. [38] examine the impacts of maize and wheat on food security in Asia and Africa. The study first identifies factors responsible for transforming the food system in the two selected regions to achieve the set targets. Empirical feedback from the study shows that maize and wheat production are significantly influenced by land degradation, climate change, and water scarcity. More so, it finds that utilization and stability pillars of food security are on the increase to promote food security. Further, it discovers that the persistent increase in production and demand for wheat and maize is inevitable given the persistent rise in population growth and per capita incomes. The need to conduciveness of the environment for food safety in Saudi Arabia constitutes the core of the research focus for Alrobaish et al. [39]. The policy measures on certain areas such as the nature of food imports, control mechanisms for imported food, and halal requirements among others are noted as fundamental especially in the areas of centralizing their implementations. Besides, Ahn & Steinbach [40] examine the drivers of trade procedures in agricultural and food sectors during COVID-19. Findings from the analysis indicate that tariffs on agricultural produce and the incidence of the COVID-19 pandemic have worsened food severity in the economy.

Schleifer & Sun [33] probe the impacts of sustainability certification on food security in developing countries by employing a systematic review through the lens of selective related studies. The study finds evidence for a positive (although weak and extremely subjective to context) association between certification, farmers' income, and food security. The study by Danse et al. [31] was motivated by the need for an in-depth understanding of the extent to which certain features of the inclusive business model (a major focus was on the internal fitness of the strategic business model) of the private sector can impact food security and nutrition in 16 selected scenarios from Africa, Asia, and Latin America. Prominent of the findings is that quality of the product or service, in addition to its affordability, marketing, and distribution strategies, is important for improving nutrition and food security. Other factors such as training and bridging institutional and cultural gaps are equally identified as sacrosanct for improving nutrition and food security. Jiren et al. [41] used Q-methodology to investigate alternative methodologies to food security and biodiversity conservation embarked upon by 50 stakeholders both locally and nationally in South-Western Ethiopia. Besides advancing the primacy of strengthening agriculture, commercialization, and profit, limiting agroecology, resilience to non-government organizations, and safeguarding biodiversity was considered as a secondary goal. Focusing on governance and foreign capital inflows, Ogunniyi et al. [32] examine the impactful roles of remittances and government quality on food and nutrition security captured by the average value of food production and the average dietary energy supply adequacy for the period 1996 to 2015 in a panel of 15 SSA countries. Empirical results based on System GMM reveal that an interplay of remittances and government quality positively impact food security.

Considering the pervasive issue of climate change, Doelman et al. [30] examine how the Paris agreements on climate change can be aligned with the standing objectives of food



security. Two preventive measures of curtailing reduction in food security were employed; increased agricultural intensification and reduced meat consumption were adopted as the two most effective ways of averting the incidence of declining food security. To achieve the core objectives, the study employs the computable general equilibrium model MAGNET coupled with the IMAGE integrated assessment model to estimate food security impacts of large-scale land-based mitigation. Based on the study, large-scale land-based mitigation (~600 Mha in 2050) causes a nearly 11% increase in food prices; 230 kcal/cap/day reduction in food availability and largely more people are noted to be facing chronic hunger. The impacts of energy are never left out of the debate. In particular, Subramaniam et al. [28] examine the impacts of biofuels on food security (FS) in a cross-section of 51 developing economies from 2011 to 2016. The study constructs an index for each of the four pillars of FS comprising availability, accessibility, stability, and utilization to capture FS. The generalized method of moments (GMM) estimates reveal a negative relationship between biofuels and the computed pillars of food security. On the contrary, Taghizadeh-Hesary et al. [29] employ the Panel-VAR model to investigate the links between energy prices and food prices for eight Asian economies over the period 2000–2016. The study finds that energy prices (oil price) positively and significantly impact food prices. Similarly, the response to oil price shocks from agricultural food prices is equally positive. Consequently, price volatility is identified as the channel of interaction between energy and food security. On the macroeconomic impacts, Oyetunde-Usman, & Olagunju, [42] employ a stochastic frontier framework in examining the determinants of food security in Nigeria with particular reference on food secure and food insecure agricultural households. Findings from the study suggest the existence of nearly 52% technical efficiencies among agricultural households. In terms of nutritional and poverty impacts on food security, El Bilali [43] reviews the potential studies on sustaining agro-food transitions and addresses the challenges of food and nutrition security. Feedback from nearly 120 of the 771 documents sourced reveals a positive and significant relationship between transition to sustainability in the agro-food arena and food availability, improved food access, better food utilization, and increased food system stability and resilience. Mary [44] examines the association between trade openness and food security in developing countries. The empirical relies on two estimation procedures. First, it estimates reverse causality between trade openness and hunger by employing irregularities in rainfall as instrumental indicators. Second, the impacts of trade openness in food (TOF) are evaluated on hunger with consideration of residual TOF as instrument variables. Empirical fallouts from the study reveal that a 10% rise in TOF leads to a corresponding increase in undernourishment by 6%.

Focusing on income disparity, Elmes [43] examines how the incidence of economic inequality in the United States has prompted escalating rates of poverty, food insecurity, and obesity for the grass-root sector of the economy. While the study posits that access to nutritious food is inviolable for improved living and social engagement, economic inequality is identified as the source of poverty, food insecurity, and obesity in the country. Campbell et al. [23] analyze the impact of climate change on the risks associated with food items such as crop, livestock, and fishery production. The study establishes that climate change has the potential to escalate food security risks and equally cause devastating impacts on the general food supply. Similarly, Richardson et al. [45] in a framework of a food security–climate change nexus finds that vulnerability to food insecurity increases under all emissions settings, and the geographic dispersion of vulnerability is, however, more severe in parts of sub-Saharan Africa and South Asia regions. Etana and Tolossa [25], in a research survey of the channel of unemployment impacts on food insecurity using binary logistic regression, find food insecurity to be more prevalent in households headed by unemployed persons. Factors such as education and economic status are found to significantly impact food insecurity. Dithmer, & Abdulai [27] examine the effect of trade openness (TO) on selected indicators of food security by employing the system GMM estimator. The results reveal that TO and economic growth positively affect dietary energy consumption, thereby promoting improvements in dietary diversity. Mahadevan &

Hoang [15] find the existence of a weak relationship between the rural poverty, while the urbans was significant, in causing food insecurity. Also, while a strong link is established for unidimensional interlock, the links are diverse and inconsistent when persistent and transient poverty are considered. Sassi [46] examines the drivers of food insecurity with particular focus on undernourishment measuring food availability, access to food, and its utilization in 40 selected SSA economies. The results emanating from the analysis reveal the significant effects of global and local food insecurity drivers.

Hannum et al. [47] conduct a survey analysis for children in 100 villages of northwest China on the tripartite relationships among poverty, food insecurity, and nutritional deprivation. Evidence from the study reveals that long-term undernourishment and food insecurity are more severe among the poorest than the literates. It also finds that lower literacy achievement is more pronounced among children that are food-insecure. Focusing on trade credit to agriculture, Mahadevan & Suardi [14] considers the challenges of food insecurity posed by insufficient or excess calories in the commodity markets in India. Two outstanding findings stemmed from the study. First, the gap in calories did not respond uniformly due to differences in individuals' calorie status, socio-economic features, social aid initiative, as well as caste and religion. Second, these impacts are influenced by rural/urban differences. Saaka & Osman, [48] employs three indicators of food security (vis-a-vis, household food insecurity access scale, household dietary diversity score, and food consumption score) to investigate the scale of household food insecurity and its impacts on the nutritional level of children 6–36 months within the Tamale Metropolis of Northern Ghana. Findings from the study have it that different indicators of household food insecurity result in varied levels. More specifically, the household food insecurity access scale is found to yield a 54% level of food insecurity and children in food-secure families are able to survive chronic malnutrition for nearly 46%. Loopstra and Tarasuk [24] probe how changes in income, employment status, and receipt of welfare influence a corresponding change in food insecurity severity among families with low income for the 2005–2007 period. Feedback from a sample of 331 families reveals the persistency of food insecurity as a common challenge for 68% with severity reaching nearly 73.4% of the sample.

Government commitments to, and their impacts on, the agriculture sector in terms of provision credit facilities to smallholders of farms in Pakistan constitute the core of the study conducted by Hussain and Thapa [26]. Analyses of primary data collected on a survey of 208 households reveal that not much has been achieved on the national credit policy in terms of demand for credit and that obtained. Also, the fact that informal sources have continued to prevail further underscores the pending challenges embattling the sector's inability to resolve the country's persistent food insecurity and malnutrition. Burchi, and De Muro [49] probe the nexuses among food, health, and the environment, and their impacts on chronic micronutrient deficiencies (otherwise known as hidden hunger). The study supports the inexplicable need to scale up food and nutrition structures with a robust agriculture system. Prior related studies, such as Kuku et al. [13], find children to be more vulnerable to food insecurity than adults. Bhattacharya et al. [50] employ the National Health and Nutrition Examination Survey data to investigate the nexus between nutritional status, poverty, and food insecurity for family members of diverse ages. The study finds that poverty leads to poor nutrition for preschool children while food insecurity does not. In addition, neither of the two indicators is significant for school age children. Trueblood, & Shapouri, [51] find that relaxing trade regulations has the potential to mitigate the prevalence of food insecurity in developing countries and equally close their food gap. Hence, expanding the scales of food production in domestic sectors is seen as an effective way to address these challenges.

The critical appraisal of the above literature on the factors hindering or enhancing food security clearly indicates apparent lacunas in the extant studies. First, the measures of food security employed in the literature have been largely narrow and restrictive. For instance, aside from the studies of Subramaniam et al. [28] and Sassi [46] which employ measures



of FS from the four pillars, others have been highly selective of either one indicator or the other. However, the pillars employed by Sassi were narrowed down to undernourishment alone for the selected 40 SSA economies. The scope of Subramaniam et al. [28], which covers a wider range of the four pillars, was generalized on developing countries. Hence, this study is an extension of the frontier on these two studies with the consideration of the four dimensions covering both undernourishment and food security in SSA. Second, recently, the preponderance of the extant literature did not consider the effects of ease of trading procedures on FS except Benoude et al. [52]. This study however differs from Benoude et al. [52] in at least four ways. First, while this study evaluates the effects of TF on all the four pillars of FS (accessibility, availability, stability, and utilization), the study of Benoude et al. [52] excludes the TF effects on the stability pillar on the ground that the effect has been indirectly accounted for through other non-FS indicators such as rainfall and temperature, political stability, and inflation. Second, the composite of the three mentioned pillars were proxied by selected indicators and not by a computed composite index. For instance, food availability is captured by average dietary energy supply adequacy, food access was captured by depth of food deficit, and food utilization is measured by access to improved sanitation. Our study employs the technique of principal component analysis (PCA) to compute the pillars using the various available indicators following Subramaniam et al. [28]. Third, while the earlier mentioned study considers the individual effects of documents, costs, and time to export as well as the aggregated index, this study unbundled TF indicators to total export costs (documents, costs, and time to export), total import costs (documents, costs, and time to import), and the aggregated from the six indicators. The computation of the TF index aligns with Sakyi et al. [53]. Fourth, in terms of scope, Benoude et al. [52] focus on 45 countries in Africa from 2006 to 2015 while this study specifically considers 35 economies in SSA from 2005 to 2019.

### 3. Method

#### 3.1. Model Specification

The theoretical justification for modelling the functional relationship between food security and trade facilitation in this study is based on the standard Malthusian and neo-Malthusian theory which holds that the prevalence of food insecurity can be attributed to uncontrolled population growth such that the number of people outgrow the amount of food supply (Azam et al. [54]). In specific terms, the theory proposes that population grows in a geometric ratio. Still, the means of subsistence, or agricultural production, grow in an arithmetic ratio, thereby militating against agricultural supply to sufficiently feed the increasing populations indeterminately (Mellos, [55]). An extended version of the theory is proposed in the neo-Malthusian theory which advances that a lack of adequate and sufficient food supply per person is a result of limited and finite land resources (Subramaniam et al., [28]; Liu et al. [21], and Schneider et al. [56]). To control population explosion, Malthus suggests two checks: positive checks (or natural checks) and preventative checks which are expected to revert the population to a level that is sustainable. This is called the Malthusian catastrophe. While a number of studies found evidence that validates the proposition advanced in the Malthusian theory (Hadush et al., [57]; Sakanko, & David, [58]), others refute the claims (Azam et al., [54]; Okunola et al., [59]).

Leveraging on the theoretical underpinning and the extant literature, specifically the most recent ones (Oguniyi et al., [32]; Subramaniam et al., [28]; Taghizadeh-Hesary et al., [29]), this study models the functional relationship between trade facilitation (TF) and food security (FS) in SSA. To achieve this, a linear dynamic panel growth model specifying the impacts of TF on food security is first specified thus:

$$FS_{i,t} = \omega_1 + \delta_2 FS_{i,t-1} + \delta_3 K_{i,t} + \delta_4 L_{i,t} + \delta_5 POP_{i,t} + \delta_6 TF_{i,t} + \delta_7 TO_{i,t} + \delta_8 InstQty_{i,t} + \delta_9 FTS_{i,t} + \mu_{i,t} \quad (1)$$

Giving that  $t = 1, 2, 3, 7 \dots \dots T$ , and  $i = 1, 2, 3, 7 \dots \dots N$

where FS stands for food security—a vector of four pillars {Food security availability pillar (FSPAV), Food security access pillar (FSPAC), Food security stability pillar (FSPAST), and Food security utility pillar (FSPUT), and the overall Food security index (FSIndex)} in country  $i$  and time  $t$ ;  $K$  is capital proxied by gross fixed capital formation (GFC) (Ajide and Ridwan, [60]);  $L$  represents investment in human capital (HC) and is captured by mean years of secondary schooling (the total population aged 15 or older); POP is population growth rate captured with percentage of population growth (Subramaniam et al., [28]; Silberberger, and Königer, [61]);  $TF$  denotes a vector of trade facilitation indicators for costs, documents, and time to import and export (Sakyi et al., [53]). These indicators are further bundled to composite indices entailing total exports (exports), total imports (imports) and trade costs (trade costs) using the principal component analysis (PCA) to examine whether the single effect of each of the indicators will conform to the aggregated index.  $TO$  is trade openness measured by Trade share in GDP (Ibrahim & Ajide, [35]; Sakyi et al., [53], [62]; Menyah et al. [63]; Omri et al., [64]).  $FTS$  denotes fixed telephone subscriptions measuring the effects of infrastructure on FS.  $InstQty$  is an aggregate of institutional measures comprising control of corruption (CC), regulatory quality (RQ), government effectiveness (GE), voice and accountability (VA), political stability (PS), and Rule of Law (RL) (Ibrahim & Ajide, [34]; Subramaniam et al., [28]; Ajide & Raheem, [65]; Asongu and Nwachukwu, [66]).  $\delta_1, \dots, \delta_9$  are parameter estimates;  $\mu_i$  is the stochastic term.

An expansion of Equation (1) can be expressed thus:

$$FS_{i,t} = \omega_1 + \delta_2 FS_{i,t-1} + \delta_3 GFC_{i,t} + \delta_4 HC_{i,t} + \delta_5 POPG_{i,t} + \delta_6 EXPORTS_{i,t} + \delta_7 IMPORTS_{i,t} + \delta_8 TRADECOSTS_{i,t} + \delta_9 TO_{i,t} + \delta_{10} InstQty_{i,t} + \delta_{11} FTS_{i,t} + \mu_{i,t} \quad (2)$$

### 3.2. Research Hypotheses

The economic intuition guiding the interplay between each of the explanatory variables and the outcome variables is presented as thus. For instance, capital formation (GFC) is expected to significantly drive food security by promoting production activities in the agricultural sector and equally driving production activities in the industrial or real sectors. Consequently, we expect a positive relationship between gross fixed capital and FS as thus,  $\delta_3 = \frac{\Delta FS}{\Delta GFC} > 0$ . Efficiency of the labor force is expected to drive production activities in the agricultural and manufacturing sector which lead to the promotion of food security. This relationship is depicted as follows:  $\delta_4 = \frac{\Delta FS}{\Delta HC} > 0$ . Population growth mostly constitutes strain on the environment due to the increasing number of food demands. The high rate of population growth reduces the number of foods who benefit from the available food stock, suggesting a positive nexus as follows:  $\delta_5 = \frac{\Delta FS}{\Delta POPG} > 0$ . The impacts of trade facilitation on food security depend on the nature of procedures which could either be efficient or inefficient, suggesting that the relationship can be direct or indirect as thus,  $\delta_6 = \frac{\Delta FS}{\Delta TF} > 0$  and  $\delta_6 = \frac{\Delta FS}{\Delta TF} < 0$ . The extent to which a country is open to the rest of the world will help facilitate the transfer of food from surplus regions to deficit regions, leading us to hypothesize a positive nexus as thus,  $\delta_7 = \frac{\Delta FS}{\Delta TO} > 0$ . The nature of institutional quality of either weak or strong will dictate the extent to which it will promote or hinder food security. Consequently, a direct or indirect association is anticipated as thus,  $\delta_8 = \frac{\Delta FS}{\Delta InstQty} > 0$  and  $\delta_8 = \frac{\Delta FS}{\Delta InstQty} < 0$ . Infrastructure is expected to drive the supply of agricultural produce across various indigenous markets, which could substantially promote food security nationally and internationally. However, if infrastructures are largely neglected, it could serve as a major hindrance to food security, as both positive and negative effects states thus,  $\delta_9 = \frac{\Delta FS}{\Delta FTS} > 0$  and  $\delta_9 = \frac{\Delta FS}{\Delta FTS} < 0$ .

### 3.3. Estimation Technique

It is pertinent to state that estimating Equation (2) requires the need to first address two fundamental problems which arise from the relationships. The first bothers on possibilities of correlation between the lagged value of the food security on the right-hand side and the unobserved country-specific effects absorbed by the disturbance variable (Dithmer, [27];

Sakyi et al., [53]). The second relates to issues bothering on heterogeneity which may likely distort the result of the GMM estimator (Oguniyi et al., [32]; Bond & Windmeijer, [67]). The aforementioned condition may make it difficult for the OLS estimator to become biased and inconsistent, even with the fixed or random effects due to the correlation of the lagged dependent variable with the error term. One alternative way to address the problem is by employing the first-difference model. Notwithstanding the preeminence of the first differencing over the panel data estimators, three major issues are associated with the method. First, a common weakness peculiar to this difference-GMM estimator is its assumption of weak instruments (Bound et al., [68]) which is often associated with biased and inefficient empirical outcomes (Baltagi, [69]). Second, the regressors in the first-difference estimator do not usually meet the condition of exogeneity. In this case, these regressors become unconditionally endogenous owing to their correlation with the error term (Roodman, [70]). Third, the method is equally associated with information loss, especially the one relating to the explanatory–explained various long-run nexus (Dithmer, [27]).

Arellano and Bover [71] provided suggestions to increasing efficiency through the consideration level equation in the model explicating the system equation, a process called the “System-GMM” estimator. In essence, the present study adopts the two-step System-GMM technique in accordance with Roodma [70] and Windmeijer [72]. Further, the efficiency and persistent nature of this estimator are usually subjected to Arellano and Bond’s [73] AR(1) and AR(2) tests of the serial correlation properties and Hansen’s [74] J-test of overidentifying restrictions.

Food security entails four basic pillars: availability, access, utilization, and stability (FAO, [4]). The four pillars each comprise sub components, all of which are well exposed in Table 1. As much as this study draws motivation from the work of Subramaniam et al., [28] for the pillars, we extended the frontier of knowledge in this regard in two ways. First, we employ the PCA to construct the index for each of the food security (FS) pillars. This has been documented in the literature as accurate and helps reduce the presence of high correlation among the variables (Asongu and Nwachukwu, [66]). Second, using the same PCA, we construct the food security index (FSIndex) for the SSA region. We employ the PCA to construct the various pillars from the various components and then, the pillars are further used to construct the aggregated FS index.

**Table 1.** The pillars and indices of food security.

Pillars	Components	Source	Index Notation
P1: Availability	Average dietary energy supply adequacy; Average value of food production; Share of dietary energy supply derived from cereals roots and tubers; Average protein supply	FAOSTAT	FS <sub>PAV</sub>
P2: Access	Gross domestic product per capita (in purchasing power equivalent sourced) <sup>WDI</sup> ; Prevalence of undernourishment; Depth of the food deficit	FAOSTAT	FS <sub>PAC</sub>
P3: Stability	Food per capita; Percent of arable land equipped for irrigation; Per capita food production variability		FS <sub>PST</sub>
P 4: Utilization	Percentage of population with access to improved drinking water sources, Percentage of population with access to sanitation facilities, Prevalence of anemia among women of reproductive age (15–49 years)	WDI	FS <sub>PUT</sub>

Note: FAOSTAT implies food and agriculture organization corporate statistical database. Superscript (WDI) GDP in P2 is sourced from World Bank’s WDI (i.e., World Development Indicators).

### 3.4. Principal Component Analysis (PCA)

This study employs the method of PCA to bundle the various components of trade facilitation (TF), institutional quality (InstQty), and food security (FS) into a single factor. The principal component analysis (PCA) is a dimensional reduction instrument that can be used to compress a large set of variables into a small set without losing relevant information

in the large set. For its accuracy, the PCA has gained wide acceptance as a statistical method to minimize the presence of high correlation among a set of variables (Asongu & Nwachukwu, [66]). Specifically, the PCA constitutes a major effective tool to extracting the combined information embodied in a larger set of correlated, observed variables. This approach is consistent with previous empirical studies on institution quality (Ajide and Raheem, [65]; Asongu and Nwachukwu, [66]), trade facilitation index (see, Sakyi et al., [53]; Seck, [62]; Portugal-Perez and Wilson, [75]) and food security (FS); this study will constitute the first attempt at constructing such indices.

This study employs the Jolliffe [76] and Kaiser [77] measure in retaining the common factors. These authors opine that common factors which are assigned eigenvalues above one or the average are to be retained. Leveraging on this criterion, we derived a composite index for aggregate trade facilitation indicator tagged trade costs from the first two principal components (PC) based on the six measures of TF in Table 2a. More so, a total import costs (TIMPCOST) index is obtained from the first PC based on the three primary TF import indicators in Table 2b. Further, a total export cost (TEXPCOST) is derived from the first PC in Table 2c.

**Table 2.** (a) Principal component analysis (PCA) for composite Trade costs. (b) Principal component analysis (PCA) for composite Total import costs. (c) Principal component analysis (PCA) for composite Total export costs (TEXPCOST).

(a)									
Principal Components	Component Matrix (Loadings)						Prop	Cumm Prop	Eigenvalue
	Import Costs	Import Documents	Import Time	Export Costs	Export Documents	Export Time			
First PC Trade cost	0.440	0.273	0.467	0.459	0.298	0.462	0.652	0.652	3.909
Second PC	−0.309	0.658	−0.145	−0.216	0.621	−0.135	0.237	5.329	1.419
First PC import cost	0.624	0.456	0.635						
First PC export cost	-	-	-	0.629	0.388	0.672	0.647	0.647	1.942
(b)									
Principal Components	Component Matrix (Loadings)			Prop	Cumm Prop	Eigenvalue			
	IMPCOST	IMPDOC	IMPTIME						
First PC TIMPCOST	0.624	0.456	0.635	0.687	0.687	2.061			
Second PC	−0.363	0.888	0.055	0.241	0.928	0.724			
Third PC	0.692	0.055	−0.719	0.072	1.000	0.216			
(c)									
Principal Components	Component Matrix (Loadings)			Prop	Cumm Prop	Eigenvalue			
	EXPCOST	EXPDOC	EXPTIME						
First PC TEXPCOST	0.629	0.388	0.673	0.647	0.647	1.942			
Second PC	−0.407	0.903	−0.139	0.287	0.934	0.859			
Third PC	0.661	0.186	−0.727	0.066	1.000	0.198			

In Table 3a, the composite index of food security (FSINDEX) is constructed from the four indicators of food security which are accessibility (FSPAC), availability (FSPAV), stability (FSPST), and utilization (FSPUT). These indicators are also a representative unit of various measures of FS as explicated in Table 1 and their PC are well explicated in Table 3b–e. The derivation of FSIINDEX is based on the first PC as evident in Table 3a. Similarly, the institutional quality composite index is obtained from the first PC based on the six indicators of institutions in Table 4a.

**Table 3.** (a) Principal component analysis (PCA) for composite Food security (FSINDEX). (b) Principal component analysis (PCA) for composite FS Availability pillar (FSPAV). (c) Principal component analysis (PCA) for composite FS Accessibility pillar (FSPAC). (d) Principal component analysis (PCA) for composite FS stability pillar (FSPST). (e) Principal component analysis (PCA) for composite FS Utilization pillar (FSPUT).

(a)							
Principal Components	Component Matrix (Loadings)				Prop	Cumm Prop	Eigenvalue
	FSPAC	FSPAV	FSPST	FSPUT			
First PC FSIINDEX	−0.344	0.585	0.466	0.568	0.528	0.528	2.110
Second PC	0.848	−0.059	0.502	0.162	0.230	0.758	0.920
Third PC	0.364	0.332	−0.729	0.476	0.146	0.904	0.583
Fourth PC	0.177	0.737	−0.002	−0.652	0.096	1.000	0.385
(b)							
Principal Components	Component Matrix (Loadings)				Prop	Cumm Prop	Eigenvalue
	ASP	ASPA	AFP	DES			
First PC FSPAV	−0.344	0.585	0.466	0.568	0.528	0.528	2.110
Second PC	0.848	−0.059	0.502	0.162	0.230	0.758	0.920
Third PC	0.364	0.332	−0.729	0.476	0.146	0.904	0.583
Fourth PC	0.177	0.737	−0.002	−0.652	0.096	1.000	0.385
(c)							
Principal Components	Component Matrix (Loadings)				Prop	Cumm Prop	Eigenvalue
	NPU	PU	GDPPC				
First PC FSPAC	0.705	0.707	−0.062	0.528	0.528	2.110	First PC FSPAC
Second PC	0.848	−0.059	0.502	0.230	0.758	0.920	Second PC
Third PC	0.364	0.332	−0.729	0.146	0.904	0.583	Third PC
(d)							
Principal Components	Component Matrix (Loadings)				Prop	Cumm Prop	Eigenvalue
	PAL	FPV	FSV				
First PC FSPST	0.659	0.648	0.383	0.463	0.463	1.389	First PC FSPST
Second PC	−0.236	−0.305	0.923	0.311	0.774	0.934	Second PC
Third PC	−0.715	0.698	0.048	0.226	1.000	0.677	Third PC
(e)							
Principal Components	Component Matrix (Loadings)				Prop	Cumm Prop	Eigenvalue
	AWR	OAP	WATER	SANI			
First PC FSPUT	0.149	0.445	0.649	0.598	0.528	0.528	2.110
Second PC	0.879	−0.449	0.152	−0.052	0.276	0.784	1.103
Third PC	0.363	0.746	−0.086	−0.553	0.165	0.949	0.659
Fourth PC	0.270	0.212	−0.741	0.578	0.052	1.000	0.206



**Table 4.** (a) Principal component analysis (PCA) for composite institution quality (INSTQTY). (b) Correlation matrix of the variables.

(a)									
Principal Components	Component Matrix (Loadings)						Prop	Cumm Prop	Eigenvalue
	CC	GE	PV	RL	RQ	VA			
First PC INSTQTY	0.438	0.202	0.401	0.477	0.428	0.443	0.667	0.667	4.003
Second PC	−0.165	0.957	0.047	−0.136	−0.189	0.013	0.149	0.817	0.899
Third PC	0.206	−0.091	0.774	−0.039	−0.444	−0.391	0.076	0.893	0.454
Fourth PC	−0.699	−0.149	0.489	−0.266	0.373	0.227	0.058	0.951	0.350
Fifth PC	0.095	0.149	−0.009	−0.043	0.651	−0.737	0.038	0.989	0.226
Sixth PC	0.492	−0.009	0.030	−0.824	0.147	0.238	0.012	1.000	0.069

(b)														
FSPAC	FSPAV	FSPST	FSPUT	FSINDEX	TEXP COST	TIMPT COST	TRADE COSTS	INSTQTY	TRADE	FTS	GFC	HC	POPG	
1	−0.26	0.02	−0.18	−0.41	0.01	0.02	0.02	0.04	0.31	0.08	0.03	−0.02	0.04	FSPAC
	1	0.33	0.66	0.84	0.1	0.14	0.12	0.03	−0.08	0.02	−0.06	−0.07	0	FSPAV
		1	0.45	0.63	0.07	0.09	0.08	−0.05	−0.09	−0.1	−0.06	−0.03	0.01	FSPST
			1	0.87	0.03	0.06	0.05	0.17	0.02	−0.05	−0.11	−0.06	−0.03	FSPUT
				1	0.07	0.1	0.09	0.06	−0.12	−0.06	−0.09	−0.06	−0.02	FSINDEX
					1	0.96	0.99	−0.01	0.06	−0.33	0.02	−0.23	0.17	TEXP COST
						1	0.99	−0.01	0.07	−0.31	−0.02	−0.25	0.2	TIMPT COST
							1	−0.01	0.06	−0.32	0	−0.25	0.19	TRADE COSTS
								1	−0.1	0.1	0.06	0.1	−0.03	INSTQTY
									1	−0.04	0.26	−0.1	0.08	TRADE
										1	−0.04	−0.04	0.19	FTS
											1	0.22	−0.18	GFC
												1	−0.51	HC
													1	POPG

3.5. Correlation Matrix

We employ the method of the correlation matrix to measure the degree of the linear and bivariate connection among the variables (Oguniyi et al., 2020; Ogundari & Awokuse, 2018; Self & Grabowski, 2004). This is expedient to investigate the direction of connection (positive or negative; strong or weak) among the variables. Going by Table 4b, it can be observed that the correlation coefficients among the set of explanatory variables (INSTQTY, TRADE, FTS, GFC, HC, POPG) are basically weak (that is, <0.50) except for the TF indicators (TEXPCOST, TIMPTCOST, TRADECOSTS,) which are highly correlated (>0.70), thus showing the presence of multicollinearity among the variables. To resolve this, we resort to specifying separate models for the TF indices.

Based on the descriptive statistics provided in Table 5, it can be observed that all the pillars of food security (FS) are negative, implying that the SSA region is in a food deficit. Similarly, the vulnerability of the region to food insecurity is further displayed in the degree of deviation from the means (pillars and index). Another insight from the descriptive statistics is the discrepancy among the pillars with the availability index taking the highest negative values followed by the access pillar. This further suggests that the two indices constitute the most severe in the region. In terms of the direction of the relationship of the explanatory variables, a positive relationship is recorded except population growth which is consistent with the stated a priori.

**Table 5.** Descriptive Statistics.

Variables	Description	Measurements	Mean	Std. Dev.	Max	Min	Signs
FSPAC	Food security access pillar	PCA computation	−0.17	1.17	4.44	−1.37	Null
FSPAV	Food security availability pillar	PCA computation	−0.31	1.56	2.92	−4.79	Null
FSPST	Food security stability pillar	PCA computation	−0.08	1.00	2.90	−1.29	Null
FSPUT	Food security utility pillar	PCA computation	−0.13	1.52	3.86	−3.86	Null
FSINDEX	Food security aggregated index	PCA computation	−0.12	1.46	4.41	−3.42	Null
	Total export costs index	PCA computation	0.18	1.58	5.32	−2.16	+
TIMPTCOST	Total import costs index	PCA computation	0.16	1.67	5.70	−2.20	+
TRADECOSTS	Trade costs index	PCA computation	0.25	2.27	7.83	−3.04	+
INSTQTY	Institutional quality index	PCA computation	0.13	2.05	4.70	−3.42	+
TRADE	Trade openness	Trade value added % of GDP	81.53	39.87	321.63	19.46	+
FTS	Infrastructure	Fixed telephone subscriptions	953,140.00	1,863,395.00	7,900,000.00	2000.00	+
GFC	Gross fixed capital	Gross fixed capital formation (% of GDP)	23.45	7.61	45.19	9.18	+
HC	Human capital	School enrollment, secondary (% gross)	47.33	25.30	99.90	9.69	+
POPG	Population growth	Population growth (annual %)	−2.36	0.91	3.84	0.16	-

#### 4. Empirical Results

The empirical results which probe the impactful relationship between trade facilitation and food security in SSA are presented in Tables 6–8 for the system GMM. Additionally, three models are specified for each of the Tables, including aggregated import, exports, and trade costs. Tables 6 and 7 contain two dependent variables, with each bringing the number of models in each Table to six. Basically, four sets of informative criteria are employed in examining the validity of the GMM models. At first, we explicate the validity and reliability of the empirical outcomes in this study through the post-tests presented in the last rows of each empirical result. As evident from the Tables, we reject the null hypothesis of no first-order residual serial correlation (AR1). In contrast, the second-order serial correlation (AR2) is not rejected. More so, both Sargan and Hansen OIR tests of instrument validity are accepted across the models.

Before providing the interpretations of the economic intuitions in the estimated models, it is very important to explain the implied meaning of the directions of effects on both TF and FS. Regarding TF, it should be noted that the nature of the procedures, whether efficient or inefficient, determines the direction of impacts. In the former case, an efficient TF is expected to enhance significant improvements in FS while the latter situation would hinder any significant improvement. Relating to FS indicators, an increase in the values of these measures implies an improvement in FS. For instance, an increase in food availability, accessibility, utilization, and stability denotes enhancement in FS. Contrarily, an inefficient TF procedure would hinder a significant improvement in FS. When inefficient TF causes reduction in FS, the level of food security and undernourishment escalates.

**Table 6.** The impacts of trade facilitation on food security (availability and access pillars).

	Food Security Access Pillar			Food Security Availability Pillar		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
l.fspav(pac)	−0.181 *** (0.069)	−0.126 *** (0.030)	−0.272 *** (0.063)	−0.151 *** (0.036)	−0.123 *** (0.040)	−0.120 ** (0.041)
texpcost	−0.516 *** (0.149)			−0.102 *** (0.028)		
timptcost		−0.412 *** (0.110)			−0.116 *** (0.029)	
tradecosts			−0.616 *** (0.151)			−0.0822 *** (0.0188)
instqty	−0.324 *** (0.089)	−0.346 *** (0.087)	−0.416 *** (0.092)	−0.045 ** (0.019)	0.014 (0.031)	0.014 (0.031)
trade	0.012 *** (0.003)	0.009 *** (0.003)	0.012 *** (0.002)	0.008 *** (0.001)	0.009 *** (0.002)	0.009 *** (0.002)
gfc	−0.044 ** (0.019)	−0.012 (0.021)	−0.023 (0.018)	−0.013 ** (0.006)	−0.023 *** (0.005)	−0.023 *** (0.005)
popg	−2.325 * (0.803)	−2.131 * (0.919)	−3.519 ** (1.068)	−0.850 *** (0.131)	−0.982 *** (0.124)	−0.986 *** (0.118)
hc	−0.077 *** (0.023)	−0.084 *** (0.026)	−0.108 *** (0.028)	−0.210 *** (0.037)	−0.026 ** (0.010)	−0.027 ** (0.010)
fts	−0.004 *** (0.001)	−0.003 *** (0.001)	−0.005 *** (0.001)	−0.006 *** (0.003)	−0.004 *** (0.001)	−0.006 *** (0.002)
_cons	5.350 * (0.682)	9.468 ** (3.174)	14.330 *** (3.698)	3.165 *** (0.635)	3.581 *** (0.856)	3.631 *** (0.852)
AR(1)	(0.058)	(0.443)	(0.471)	(0.000)	(0.001)	(0.001)
AR(2)	(0.358)	(0.291)	(0.374)	(0.591)	(0.632)	(0.637)
Sargan OIR	(0.734)	(0.765)	(0.72)	(0.000)	(0.000)	(0.000)
Hansen OIR	(0.884)	(0.799)	(0.994)	(0.356)	(0.482)	(0.489)
DHT for instruments						
(a) instruments in level						
H Excluding group	(0.617)	(0.365)	(0.476)	(0.035)	(0.039)	(0.041)
Diff(null, =exogenous)	(0.877)	(0.904)	(0.135)	(0.910)	(0.972)	(0.871)
(b) IV(years, eq (diff))						
H Excluding group	(0.850)	(0.752)	(0.990)	(0.365)	(0.422)	(0.430)
Diff(null, =exogenous)	(0.957)	(0.921)	(0.897)	(0.268)	(0.932)	(0.874)
Fishers test	289.2 ***	150.7 ***	130.5 ***	156.6 ***	174.1 ***	0.222 ***
Instruments	32	32	32	32	32	32
Country(s)	34	34	34	34	34	34
Observation	97	93	93	148	142	142

\*, \*\*, and \*\*\* denote 10%, 5%, and 1% significance levels.

The empirical results presented in Table 6 in models 1–3 show that the various indices of trade facilitation (import, export, and trade cost) all exert a negative impact on food security in SSA. The intuition derivable from this is that TF as a whole serves as a hindrance on availability of food supplies in the region. Specifically, TF as expedited in the models would hinder food availability by halting the import of food items which are needed to supplement the shortages in the home country. The burdensome procedures required in importing food items halt the reliable option of sourcing food from the external market. Also, the inefficient TF constitutes a major setback for small holder farmers in expanding their productive capacity through the exportation of farm produce in the international market. The number of days which take too long to clear goods at the port, too many documents requirements, and high costs involved all affect the majority of food exports which are mostly perishable and as such, easily become rotten in transit. Besides that, the incidence of inefficient TF hinders the competitiveness of firms who are involved in

agro-business among others. Hence, the negative impacts as elucidated in Table 6 can thus be implied such that any percentage increase in inefficiency of TF leads to a corresponding decrease in food availability to the populace in the SSA region. A similar trend is observable for the relationship between TF and the access pillar of food security in SSA. This implies that the high cost of trade in food items results in high production costs for farmers, the burden of which is shifted to the final consumers in the form of increased prices of food items. The hike in the price of agricultural products reduces consumers' purchasing power and thus reduces access to food. The complicated trade procedures involved in the exporting and importing of commodities (such as staple food and the likes) have resulted in a low record of intra-African trade which stood at nearly 17% in 2017 compared to Europe, 69%; Asia, 59%; and North America, 31% (UNECA, [78]).

**Table 7.** The impacts of trade facilitation on food security (stability and utilization).

	Food Security Stability Pillar			Food Security Utility Pillar		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
<b>L.fspst(put)</b>	<b>−0.166 ***</b> (0.032)	<b>−0.213 ***</b> (0.031)	<b>−0.214 ***</b> (0.031)	<b>−0.349 ***</b> (0.033)	<b>−0.291 ***</b> (0.022)	<b>−0.291 ***</b> (0.022)
texpcost	0.008 (0.050)			0.146 (0.336)		
timptcost		0.060 (0.048)			0.034 (0.354)	
tradecosts			0.035 (0.033)			0.007 (0.244)
<b>instqty</b>	<b>−0.116 ***</b> (0.012)	<b>−0.115 ***</b> (0.009)	<b>−0.118 ***</b> (0.009)	<b>−0.176 ***</b> (0.039)	<b>−0.185 ***</b> (0.037)	<b>−0.187 ***</b> (0.040)
<b>trade</b>	<b>0.007 ***</b> (0.001)	<b>0.008 ***</b> (0.001)	<b>0.008 ***</b> (0.001)	<b>0.007 ***</b> (0.002)	<b>0.008 ***</b> (0.002)	<b>0.008 ***</b> (0.001)
gfc	<b>−0.014 *</b> (0.008)	<b>−0.026 *</b> (0.011)	<b>−0.025 *</b> (0.011)	<b>−0.030 *</b> (0.012)	0.011 (0.021)	0.012 (0.019)
popg	<b>−0.523 **</b> (0.209)	<b>−0.579 **</b> (0.202)	<b>−0.571 **</b> (0.217)	<b>−2.255 ***</b> (0.622)	<b>−2.299 ***</b> (0.429)	<b>−2.392 ***</b> (0.516)
hc	0.015 (0.011)	0.004 (0.011)	0.003 (0.011)	<b>−0.092 ***</b> (0.022)	<b>−0.094 ***</b> (0.020)	<b>−0.096 ***</b> (0.022)
fts	<b>−0.005 ***</b> (0.001)	<b>−0.008 **</b> (0.003)	<b>−0.007 ***</b> (0.002)	<b>−0.005 **</b> (0.002)	<b>−0.004 **</b> (0.002)	<b>−0.006 ***</b> (0.002)
_cons	0.883 (0.925)	1.408 (1.148)	1.471	<b>10.91 ***</b> (1.134)	<b>10.28 ***</b> (2.521)	<b>10.60 ***</b> (2.400)
AR(1)	(0.006)	(0.015)	(0.015)	(0.010)	(0.010)	(0.011)
AR(2)	<b>(0.955)</b>	<b>(0.572)</b>	<b>(0.542)</b>	<b>(0.709)</b>	<b>(0.779)</b>	<b>(0.781)</b>
Sargan OIR	(0.000)	(0.000)	(0.000)	<b>(0.618)</b>	<b>(0.645)</b>	(0.646)
Hansen OIR	<b>(0.552)</b>	<b>(0.576)</b>	<b>(0.562)</b>	<b>(0.530)</b>	<b>(0.329)</b>	<b>(0.332)</b>
<b>DHT for instruments</b>						
<b>(a) instruments in level</b>						
H Excluding group	<b>(0.144)</b>	<b>(0.168)</b>	<b>(0.182)</b>	<b>(0.293)</b>	<b>(0.088)</b>	<b>(0.102)</b>
Diff(null, =exogenous)	<b>(0.861)</b>	<b>(0.853)</b>	<b>(0.822)</b>	<b>(0.636)</b>	<b>(0.667)</b>	<b>(0.637)</b>
<b>(b) IV(years, eq (diff))</b>						
H Excluding group	<b>(0.540)</b>	<b>(0.551)</b>	<b>(0.539)</b>	<b>(0.462)</b>	<b>(0.273)</b>	<b>(0.277)</b>
Diff(null, =exogenous)	<b>(0.375)</b>	<b>(0.451)</b>	<b>(0.434)</b>	<b>(0.855)</b>	<b>(0.781)</b>	<b>(0.752)</b>
Fishers test	<b>714 ***</b>	<b>679.2 ***</b>	<b>833.3 ***</b>	<b>51.5 ***</b>	<b>354.4 ***</b>	<b>404.5 ***</b>
Instruments	32	32	32	26	26	26
Country(s)	34	34	34	34	34	34
Observation	173	166	166	169	162	162

\*, \*\*, and \*\*\* denote 10%, 5%, and 1% significance levels.

**Table 8.** The impacts of trade facilitation on food security (aggregated index).

	Food Security Aggregated Index		
	Model 1	Model 2	Model 3
L.fsindex	−0.301 *** (0.040)	−0.256 *** (0.031)	−0.269 *** (0.031)
texpcost	−1.379 * (0.566)		
timptcost		−0.797 ** (0.324)	
tradecosts			−0.839 * (0.372)
instqty	−0.324 *** (0.033)	−0.252 *** (0.051)	−0.260 *** (0.041)
trade	0.005 (0.002)	0.001 (0.002)	0.002 (0.002)
gfc	−0.075 *** (0.013)	−0.051 ** (0.020)	−0.062 ** (0.021)
popg	−0.989** (0.468)	−1.498 ** (0.516)	−1.286 * (0.487)
hc	−0.032 ** (0.012)	−0.041 ** (0.014)	−0.034 ** (0.013)
fts	−0.005 ** (0.002)	−0.008 *** (0.002)	−0.006 *** (0.002)
_cons	4.793 ** (1.665)	5.831 ** (1.802)	5.185 ** (1.787)
AR(1)	(0.584)	(0.650)	(0.638)
AR(2)	(0.358)	(0.349)	(0.367)
Sargan OIR	(0.384)	(0.263)	(0.330)
Hansen OIR	(0.583)	(0.419)	(0.421)
<b>DHT for instruments</b>			
<b>(a) instruments in level</b>			
H Excluding group	(0.136)	(0.137)	(0.113)
Diff(null, =exogenous)	(0.872)	(0.688)	(0.738)
<b>(b) IV(years, eq (diff))</b>			
H Excluding group	(0.819)	(0.635)	(0.668)
Diff(null, =exogenous)	(0.037)	(0.045)	(0.035)
Fishers test	30.8 ***	14.9 ***	18 ***
Instruments	26	26	26
Country(s)	34	34	34
Observation	78	74	74

\*, \*\*, and \*\*\* denote 10%, 5 %, and 1% significance levels.

Table 7 explicates the extent to which trade facilitation indicators impact food security's stability and utilization pillars. Models 1–3 specify the stability pillar while models 4–6 entail the utilization pillar. All the indicators of TF are not significant in explaining the variation in food stability and utilization of food security in SSA. However, the impact of TF indicators on the overall index of food security is significantly negative, which conforms to the main results in Table 6. This implies that TF remains a hindrance on food security in the SSA region giving the fact that the complicated trading procedures on agriculture products and their supply chain exacerbate the prevalence of food insecurity in the region. This has equally prevented the transfer of food from surplus economies of the region to deficit economies. For instance, Kenya has been noted to have experienced food-deficits while countries such as Tanzania and Uganda have a food surplus (Allen, [79]). Transferring food from these countries to a country like Kenya becomes more difficult as a result of the inefficiency of imports and exports procedures. Buttressing this standpoint, the World Bank [80] report remarked that the food supply in the West African region, for instance, could be tripled if measures that encourage trade openness are institutionally adopted.



Considering other control variables, the impact of institutions on food security is negative for all the pillars and the aggregated index. A number of reasons have been advanced in the literature to explain the negative impacts of institutional quality on food security both from disaggregated and aggregated viewpoints. In particular terms, Bain et al. [81] noted that pervasiveness of corruption had escalated the incidence of malnutrition and its related outcomes. He opined that the various financial interventions which have been offered to the SSA region failed to mitigate the prevalence of nutritional insecurity due to misappropriation of funds. This view is equally supported by Fan et al. [82] and Pardey, Alston, and Piggott [83] in terms of government ineffectiveness, and Bello-Schünemann and Moyer [84] in terms of political instability (Maxwell, [85]; Deaton & Lipka, [86]; Simmons, [87]). Also, trade openness exerts positive and statistically significant signs on all the models, which implies that, since domestic sectors producing food supplies are not capable of meeting the excessive demand, there is an inevitable need to import from surplus economies and domestic sectors with excessive food supplies, requiring external markets to expand their productive capacities. Additionally, the negative impacts of gross fixed capital can be blamed on the investment concentration on other sectors of the economy which do not have direct contribution to food production at the expense of the agriculture sector.

Furthermore, the impact of population growth is negative and statistically significant. This is in conformity with our a priori expectation of the deleterious effects a surging population rate has on food security and equally agrees well with Oguniyi et al., [32] and Bremner [88]. While the negative sign of infrastructure is well exposed in the light of the infrastructural deficits in the form of bad road networks, lack of adequate storage facilities, dilapidated electricity supplies, and unavailability of other basic social amenities on the one hand, the negative impacts of human capital is a worrisome case giving its contradiction to extant studies on the related subject matter (see Ogundari & Awokuse, [89]; Burchi and De Muro, [49]). However, the economic intuition that can be deduced from the feedback is that a trade-off exists between human capital and food security through the agricultural channel. This is predicated on the ground that most of the workforces in the agriculture sector contributing to the production of food supplies are majorly unskilled with low income earning. A further educational attainment tends to necessitate their mobility to the industrial sector with better pay. Consequently, the agriculture sector loses more workers amidst the growing food demand from the exploding population. In the end, human capital further aggravates the prevalence of food insecurity in the SSA region.

## 5. Conclusions, Caveats, and Future Research Directions

This study investigates the nexus between trade facilitation (TF) and food security in a panel of 34 sub-Saharan countries for the period 2005–2019. The study employs the Two-Step System-Generalized Method of Moments estimator which caters for unobserved heterogeneity and potential endogeneity of the main explanatory variables. For easy traceability of the empirical findings, the study resorts to the computation of three indices of trade facilitation comprising total imports, total exports, and trade costs using principal component analysis (PCA). In addition, PCA was also employed to construct four pillars of food security (FS) comprising availability, accessibility, stability, and utilization, and the aggregated index (FSindex). The results obtained from the model estimated reveal that FT indicators negatively impact FS from the four dimensions in SSA. While it is noted that this result is against the a priori expectation of the anticipated positive signs, it however portrays the reality of the economic phenomenon in SSA. Consequently, instead of promoting food security, TF in its present inefficient form has continued to hinder food security as suggested by the prevailing burdensome procedures involved in the exporting and importing of staple food items. It is important to note that the issue of food security is further worsened by the weak institutional quality in the region. While it is widely held in the literature that institutional quality is very important and highly significant in harnessing food supply from both import and export ends, the weak nature of such institutions further aggravates the

challenges posed by inefficient TF. In addition to the foregoing, it should be noted that while trade openness exerts positive impacts on food security, variables such as human capital, gross fixed capital, population growth, and infrastructure all exert negative impacts.

It should be noted that while our empirical findings largely report an overall negative nexus between TF and food security (FS), there is still quite an abundance of benefits that TF holds as an effective tool in combating food insecurity prevalence in developing regions such as SSA. However, achieving this is subject to the readiness to embrace the existing trade facilitation agreements (TFA) reached at the various protocols of the WTO. Hence, we recommend that to address the various negative impacts of TF on food security in SSA, the government and its relevant agencies involved in the export and import activities of the various countries in SSA should key into TFA fully. This is predicated on the ground that implementing TFA would help increase the efficiency of logistics involved in cross border trade in these countries and equally bring about gains for both agriculture and food trade through the reduction in the cost of trading. To resolve the impeding impacts of TF on the various pillars of food security (availability, accessibility, stability, and utility), drastic efforts should be made to harmonize import and export procedures, especially for goods in transit, to avail the region's unswerving choices to augment domestic food deficits from external markets. Doing this will equally help the region advance from being net importers of food and other goods to net exporters and equally enhance intra-regional trade in SSA.

This study opens viable windows for continuous empirical research on the subject matter, particularly in the areas relating to other regions of the world. Also, the need to embark on the mediating role of institutional quality between TF and FS in the SSA region holds a promising research terrain to be further exploited. This is highly important considering the fact that institutions have been identified as key drivers of economic outcomes from both angles of boost and bottlenecks, depending on whether such institutional qualities are strong or weak. This should be assessed from both aggregated and disaggregated angles as doing this will help enhance robust policy measures. On the last note, we see the efficacy of the need to probe the determinants of food security in the SSA region with robust analyses.

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## References

1. Gutterman, A. *Older Persons' Right to Adequate Food*; Available at SSRN 4275564; FAO: Rome, Italy, 2022.
2. United Nations. Commission on Human Rights: Report of the 30th Session. Available online: <https://digitallibrary.un.org/record/220199?ln=en> (accessed on 25 November 2022).
3. Ibrahim, R.L.; Yu, Z.; Hassan, S.; Ajide, K.B.; Tanveer, M.; Khan, A.R. Trade Facilitation and Agriculture Sector Performance in Sub-Saharan Africa: Insightful Policy Implications for Economic Sustainability. *Front. Environ. Sci.* **2022**, *10*, 962838. [[CrossRef](#)]
4. Food & Agriculture Organization. *Food Security*; Development Economics Division (June 2006); FAO: Rome, Italy, 2012.
5. Makwata, L.C.J. The Role of Military Forces in National Food Security Strategies a Comparative Analysis of Egypt and Kenya. Ph.D. Dissertation, University of Nairobi, Nairobi, Kenya, 2022.
6. Food & Agriculture Organization. *Trade Reforms and Food Security: Conceptualizing the Linkages*; FAO: Rome, Italy, 2003; pp. 43–61.
7. Kareem, F.O.; Martínez-Zarzoso, I.; Brümmer, B. What Drives Africa's Inability to Comply with EU Standards? Insights from Africa's Institution and Trade Facilitation Measures. *Eur. J. Dev. Res.* **2022**, 1–36. [[CrossRef](#)]
8. Kuteyi, D.; Winkler, H. Logistics Challenges in Sub-Saharan Africa and Opportunities for Digitalization. *Sustainability* **2022**, *14*, 2399. [[CrossRef](#)]
9. Safaeimanesh, S.; Jenkins, G.P. Estimation of the potential economic welfare to be gained by the South African Customs Union from trade facilitation. *South Afr. J. Econ. Manag. Sci.* **2021**, *24*, 1–14. [[CrossRef](#)]

10. Nyameino, D.; Kagira, B.; Njuki, S. *Maize Market Assessment and Baseline Study for Kenya*; Regional Agricultural Trade Expansion Support Program: Nairobi, Kenya, 2003.
11. Tschirley, D.L.; Abdula, D.C.; Weber, M.T. *Toward Improved Maize Marketing and Trade Policies to Promote Household Food Security in Central and Southern Mozambique*; No. 1093-2016-88075; Michigan State University: East Lansing, MI, USA, 2006.
12. Molini, V. Food security in Vietnam during the 1990s: The empirical evidence. In *Food Security: Indicators, Measurement, and the Impact of Trade Openness*; United Nations University: Tokyo, Japan, 2007; pp. 129–149.
13. Kuku, O.; Gundersen, C.; Garasky, S. Differences in food insecurity between adults and children in Zimbabwe. *Food Policy* **2011**, *36*, 311–317. [[CrossRef](#)]
14. Mahadevan, R.; Suardi, S. Regional differences pose challenges for food security policy: A case study of India. *Reg. Stud.* **2014**, *48*, 1319–1336. [[CrossRef](#)]
15. Mahadevan, R.; Hoang, V. Is there a link between poverty and food security? *Soc. Indic. Res.* **2016**, *128*, 179–199. [[CrossRef](#)]
16. Brown, L.R. World population growth, soil erosion, and food security. *Science* **1981**, *214*, 995–1002. [[CrossRef](#)]
17. Masters, W.; Djurfeldt, A.A.; De Haan, C.; Hazell, P.; Jayne, T.; Jirström, M.; Reardon, T. Urbanization and farm size in Asia and Africa: Implications for food security and agricultural research. *Glob. Food Secur.* **2013**, *2*, 156–165. [[CrossRef](#)]
18. Tian, J.; Bryksa, B.C.; Yada, R.Y. Feeding the world into the future – food and nutrition security: The role of food science and technology. *Front. Life Sci.* **2016**, *9*, 155–166. [[CrossRef](#)]
19. Rasul, G.; Sharma, B. The nexus approach to water–energy–food security: An option for adaptation to climate change. *Clim. Policy* **2016**, *16*, 682–702. [[CrossRef](#)]
20. Dawson, T.P.; Perryman, A.H.; Osborne, T.M. Modelling impacts of climate change on global food security. *Clim. Chang.* **2014**, *134*, 429–440. [[CrossRef](#)]
21. Liu, Y.S.; Wang, J.Y.; Long, H.L. Analysis of arable land loss and its impact on rural sustainability in Southern Jiangsu Province of China. *J. Environ. Manag.* **2010**, *91*, 646–653. [[CrossRef](#)] [[PubMed](#)]
22. McMichael, P.; Schneider, M. Food security politics and the Millennium Development Goals. *Third World Q.* **2011**, *32*, 119–139. [[CrossRef](#)]
23. Campbell, B.M.; Vermeulen, S.J.; Aggarwal, P.K.; Corner-Dolloff, C.; Girvetz, E.; Loboguerrero, A.M.; Ramirez-Villegas, J.; Rosenstock, T.; Sebastian, L.; Thornton, P.K.; et al. Reducing risks to food security from climate change. *Glob. Food Secur.* **2016**, *11*, 34–43. [[CrossRef](#)]
24. Loopstra, R.; Tarasuk, V. Severity of household food insecurity is sensitive to change in household income and employment status among low-income families. *J. Nutr.* **2013**, *143*, 1316–1323. [[CrossRef](#)]
25. Etana, D.; Tolossa, D. Unemployment and food insecurity in urban Ethiopia. *Afr. Dev. Rev.* **2017**, *29*, 56–68. [[CrossRef](#)]
26. Hussain, A.; Thapa, G.B. Smallholders’ access to agricultural credit in Pakistan. *Food Secur.* **2012**, *4*, 73–85. [[CrossRef](#)]
27. Dithmer, J.; Abdulai, A. Does trade openness contribute to food security? A dynamic panel analysis. *Food Policy* **2017**, *69*, 218–230. [[CrossRef](#)]
28. Subramaniam, Y.; Masron, T.A.; Azman NH, N. The impact of biofuels on food security. *Int. Econ.* **2019**, *160*, 72–83. [[CrossRef](#)]
29. Taghizadeh-Hesary, F.; Rasoulnezhad, E.; Yoshino, N. Energy and food security: Linkages through price volatility. *Energy Policy* **2019**, *128*, 796–806. [[CrossRef](#)]
30. Doelman, J.C.; Stehfest, E.; Tabeau, A.; van Meijl, H. Making the Paris agreement climate targets consistent with food security objectives. *Glob. Food Secur.* **2019**, *23*, 93–103. [[CrossRef](#)]
31. Danse, M.; Klerkx, L.; Reintjes, J.; Rabbinge, R.; Leeuwis, C. Unravelling inclusive business models for achieving food and nutrition security in BOP markets. *Glob. Food Secur.* **2020**, *24*, 100354. [[CrossRef](#)]
32. Ogunniyi, A.I.; Mavrotas, G.; Olagunju, K.O.; Fadare, O.; Adedoyin, R. Governance quality, remittances and their implications for food and nutrition security in Sub-Saharan Africa. *World Dev.* **2020**, *127*, 104752. [[CrossRef](#)]
33. Schleifer, P.; Sun, Y. Reviewing the impact of sustainability certification on food security in developing countries. *Glob. Food Secur.* **2020**, *24*, 100337. [[CrossRef](#)]
34. Ibrahim, R.L.; Ajide, K.B. Trade facilitation, institutional quality, and sustainable environment: Renewed evidence from Sub-Saharan African Countries. *J. Afr. Bus.* **2020**, *23*, 281–303. [[CrossRef](#)]
35. Ibrahim, R.L.; Ajide, K.B. Trade facilitation and environmental quality: Empirical evidence from some selected African countries. *Environ. Dev. Sustain.* **2021**, *24*, 1282–1312. [[CrossRef](#)]
36. Jiahao, S.; Ibrahim, R.L.; Bello, K.A.; Oke, D.M. Trade facilitation, institutions, and sustainable economic growth. Empirical evidence from Sub-Saharan Africa. *Afr. Dev. Rev.* **2022**, *43*, 201–214.
37. Raheem, D.; Dayoub, M.; Birech, R.; Nakiyemba, A. The Contribution of Cereal Grains to Food Security and Sustainability in Africa: Potential Application of UAV in Ghana, Nigeria, Uganda, and Namibia. *Urban Sci.* **2021**, *5*, 8. [[CrossRef](#)]
38. Grote, U.; Fasse, A.; Nguyen, T.T.; Erenstein, O. Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Front. Sustain. Food Syst.* **2021**, *4*, 317. [[CrossRef](#)]
39. Alrobaish, W.S.; Vlerick, P.; Luning, P.A.; Jacxsens, L. Food safety governance in Saudi Arabia: Challenges in control of imported food. *J. Food Sci.* **2021**, *86*, 16–30. [[CrossRef](#)]
40. Ahn, S.; Steinbach, S. COVID-19 trade actions in the agricultural and food sector. *J. Food Distrib. Res.* **2021**, *52*, 51–75.
41. Jiren, T.S.; Dorresteyn, I.; Hanspach, J.; Schultner, J.; Bergsten, A.; Manlosa, A.; Jager, N.; Senbeta, F.; Fischer, J. Alternative discourses around the governance of food security: A case study from Ethiopia. *Glob. Food Secur.* **2020**, *24*. [[CrossRef](#)]

42. Oyetunde-Usman, Z.; Olagunju, K.O. Determinants of Food Security and Technical Efficiency among Agricultural Households in Nigeria. *Economies* **2019**, *7*, 103. [CrossRef]
43. El Bilali, H. Research on agro-food sustainability transitions: Where are food security and nutrition? *Food Secur.* **2019**, *11*, 559–577. [CrossRef]
44. Mary, S. Hungry for free trade? Food trade and extreme hunger in developing countries. *Food Secur.* **2019**, *11*, 461–477. [CrossRef]
45. Richardson, K.J.; Lewis, K.H.; Krishnamurthy, P.K.; Kent, C.; Wiltshire, A.J.; Hanlon, H.M. Food security outcomes under a changing climate: Impacts of mitigation and adaptation on vulnerability to food insecurity. *Clim. Change* **2018**, *147*, 327–341. [CrossRef]
46. Sassi, M.A.; Spatial Nonsi, M. 201 Analysis of the Determinants of Food Insecurity in Subanalysis o Africa. *Afr. Dev. Rev.* **2015**, *27*, 92–105. [CrossRef]
47. Hannum, E.; Liu, J.; Frongillo, E.A. Poverty, food insecurity and nutritional deprivation in rural China: Implications for children’s literacy achievement. *Int. J. Educ. Dev.* **2014**, *34*, 90–97. [CrossRef]
48. Saaka, M.; Osman, S.M. Does household food insecurity affect the nutritional status of preschool children aged 6–36 months? *Int. J. Popul. Res.* **2013**, *2013*, 304169. [CrossRef]
49. Burchi, F.; De Muro, P. *Education for Rural People: A Neglected Key to Food Security*; Departmental Working Papers of Economics—University ‘Roma Tre’0078; Department of Economics—University Roma Tre: Rome, Italy, 2007.
50. Bhattacharya, J.; Currie, J.; Haider, S. Poverty, food insecurity, and nutritional outcomes in children and adults. *J. Health Econ.* **2004**, *23*, 839–862. [CrossRef]
51. Trueblood, M.A.; Shapouri, S. *Implications of Trade Liberalization on Food Security of Low-Income Countries*; No. 1474-2016-120811; USDA: Washington, DC, USA, 2001.
52. Bonuedi, I.; Kamasa, K.; Opoku EE, O. Enabling trade across borders and food security in Africa. *Food Secur.* **2020**, *12*, 1121–1140. [CrossRef]
53. Sakyi, D.; Villaverde, J.; Maza, A.; Bonuedi, I. The effects of trade and trade facilitation on economic growth in Africa. *Afr. Dev. Rev.* **2017**, *29*, 350–361. [CrossRef]
54. Azam, M.; Khan, H.N.; Khan, F. Testing Malthusian’s and Kremer’s population theories in developing economy. *Int. J. Soc. Econ.* **2020**, *47*, 523–538. [CrossRef]
55. Mellos, K. Neo-Malthusian theory. In *Perspectives on Ecology*; Palgrave Macmillan: London, UK, 1988; pp. 15–42.
56. Schneider, U.A.; Havlík, P.; Schmid, E.; Valin, H.; Mosnier, A.; Obersteiner, M.; Böttcher, H.; Skalský, R.; Balkovič, J.; Sauer, T. Impacts of population growth, economic development, and technical change on global food production and consumption. *Agric. Syst.* **2011**, *104*, 204–215. [CrossRef]
57. Hadush, M.; Holden, S.T.; Tilahun, M. Does population pressure induce farm intensification? Empirical evidence from Tigray Region, Ethiopia. *Agric. Econ.* **2019**, *50*, 259–277. [CrossRef]
58. Sakanko, M.A.; David, J. An Econometric Validation of Malthusian Theory: Evidence in Nigeria. *Signifikan J. Ilmu Ekon.* **2018**, *7*, 77–90. [CrossRef]
59. Okunola, A.M.; Nathaniel, S.P.; Festus, V.B. Revisiting population growth and food production nexus in Nigeria: An ARDL approach to cointegration. *Agric. Resour. Econ. Int. Sci. E-J.* **2018**, *4*, 41–51. [CrossRef]
60. Ajide, K.; Ridwan, I. Energy consumption, environmental contaminants, and economic growth: The G8 experience. *Appl. Econom.* **2018**, *51*, 58–83.
61. Silberberger, M.; Königer, J. Regulation, trade and economic growth. *Econ. Syst.* **2016**, *40*, 308–322. [CrossRef]
62. Sakyi, D.; Bonuedi, I.; Opoku EE, O. Trade facilitation and social welfare in Africa. *J. Afr. Trade* **2018**, *5*, 35–53. [CrossRef]
63. Menyah, K.; Nazlioglu, S.; Wolde-Rufael, Y. Financial development, trade openness and economic growth in African countries: New insights from a panel causality approach. *Econ. Model.* **2014**, *37*, 386–394. [CrossRef]
64. Omri, A.; Daly, S.; Rault, C.; Chaibi, A. Financial development, environmental quality, trade and economic growth: What causes what in MENA countries. *Energy Econ.* **2015**, *48*, 242–252. [CrossRef]
65. Ajide, K.B.; Raheem, I.D. Institutions-FDI nexus in ECOWAS countries. *J. Afr. Bus.* **2016**, *17*, 319–341. [CrossRef]
66. Asongu, S.A.; Nwachukwu, J.C. The mobile phone in the diffusion of knowledge for institutional quality in sub-Saharan Africa. *World Dev.* **2016**, *86*, 133–147. [CrossRef]
67. Windmeijer, F.; Bond, S. Finite Sample Inference for GMM Estimators in Linear Panel Data Models. 2002. Available online: <https://www.econstor.eu/bitstream/10419/79371/1/362533156.pdf> (accessed on 25 November 2022). [CrossRef]
68. Bound, J.; Jaeger, D.; Baker, R. Problems with instrumental variable estimation when the correlation between the instruments and the endogenous explanatory variables is weak. *J. Am. Stat. Assoc.* **1995**, *90*, 443.
69. Baltagi, B.H. Forecasting with panel data. *J. Forecast.* **2008**, *27*, 153–173. [CrossRef]
70. Roodman, D. How to do Xtabond2: An Introduction to Difference and System GMM in Stata. *Stata Journal: Promot. Commun. Stat. Stata* **2009**, *9*, 86–136. [CrossRef]
71. Arellano, M.; Bover, O. Another look at the instrumental variable estimation of error-components models. *J. Econ.* **1995**, *68*, 29–51. [CrossRef]
72. Windmeijer, F. A finite sample correction for the variance of linear efficient two-step GMM estimators. *J. Econ.* **2005**, *126*, 25–51. [CrossRef]



73. Arellano, M.; Bond, S. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev. Econ. Stud.* **1991**, *58*, 277–297. [[CrossRef](#)]
74. Hansen, L.P. Large Sample Properties of Generalized Method of Moments Estimators. *Econometrica* **1982**, *50*, 1029. [[CrossRef](#)]
75. Portugal-Perez, A.; Wilson, J.S. Export performance and trade facilitation reform: Hard and soft infrastructure. *World Dev.* **2012**, *40*, 1295–1307.
76. Jolliffe, I.T. *Principal Component Analysis for Special Types of Data*; Springer: New York, NY, USA, 2002; pp. 338–372.
77. Kaiser, H.F. An index of factorial simplicity. *Psychometrika* **1974**, *39*, 31–36. [[CrossRef](#)]
78. UNECA. Economic Report on Africa 2015: Industrializing through Trade. 2015. Available online: <https://hdl.handle.net/10855/22767> (accessed on 25 November 2022).
79. Allen, S. *Food Security in East Africa from a Trade Facilitation Perspective*; GREAT Insights; ECDPM: Maastricht, The Netherlands, 2012; Volume 1.
80. World Bank. *The State of Social Safety Nets 2015*; The World Bank: Washington, DC, USA, 2015.
81. Bain, L.E.; Awah, P.K.; Geraldine, N.; Kindong, N.P.; Siga, Y.; Bernard, N.; Tanjeko, A.T. Malnutrition in Sub-Saharan Africa: Burden, causes and prospects. *Pan Afr. Med. J.* **2013**, *15*. [[CrossRef](#)]
82. Fan, S.; Torero, M.; Headey, D. *Urgent Actions Needed to Prevent Recurring Food Crises*; IFPRI Policy Brief 16; International Food Policy Research Institute: Washington, DC, USA, 2011.
83. Pardey, P.G.; Alston, J.M.; Piggott, R. *Agricultural R and D in the Developing World*; International Food Policy Research Institute: Washington, DC, USA, 2006.
84. Bello-Schünemann, J.; Moyer, J.D. Structural pressures and political instability-trajectories for sub-Saharan Africa. *ISS Afr. Rep.* **2018**, *9*, 1–32.
85. Maxwell, D. Food security and its implications for political stability: A humanitarian perspective. In *FAO High Level Expert Forum on Addressing Food Insecurity in Protracted Crises 2012*; FAO: Rome, Italy, 2012.
86. Deaton, B.J.; Lipka, B. Political instability and food security. *J. Food Secur.* **2015**, *3*, 29–33. [[CrossRef](#)]
87. Simmons, E. *Recurring Storms: Food Insecurity, Political Instability, and Conflict*; CSIS, Center for Strategic & International Studies: Washington, DC, USA, 2017.
88. Bremner, J. Population and food security: Africa’s challenge. In *Policy Brief*; Population Reference Bureau: Washington, DC, USA, 2012.
89. Ogundari, K.; Awokuse, T. Human capital contribution to economic growth in Sub-Saharan Africa: Does health status matter more than education? *Econ. Anal. Policy* **2018**, *58*, 131–140. [[CrossRef](#)]

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