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Agricultural trade liberalisation, agricultural total factor productivity growth and food security in Africa*

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ABSTRACT

The study draws inference on the impact of agricultural trade openness, total factor productivity (TFP) growth, and domestic agriculture support on food security in Africa. To retain estimates efficiency and consistency in the presence of complex error terms, we employed the Panel-Corrected-Standard-Error (PCSE) estimator on panel data spanning 2005–2016 for 13 African countries. Results suggest that agricultural trade liberalisation and TFP have significant and favourable effects. Moreover, we find that reducing agricultural support beyond distortion-free levels enhances food security. Further to trade openness, we call for export growth-oriented domestic support anchored on agricultural human-capital development, innovation, and research and development.

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Q17; Q18

1. Introduction

Achieving food security remains a global, regional, national, and household priority. Right at the top, the second Sustainable Development Goal envisages a food secure world, free of hunger with better nutrition (Food and Agriculture Organisation (FAO), Economic Commission for Africa (ECA), and African Union Commission (AUC) 2020). In Africa, achieving food security is critical in eliminating poverty, hunger, and malnutrition, all key priority areas of Agenda 2063 (AUC 2015). Accordingly, regional economic groupings in Africa and individual countries have also formulated various policies around ending food insecurity. A key element of such interventions is building food systems that promote nutrition-sensitive agriculture (World Bank 2020). Among such strategies, notable emphasis has been put on trade liberalisation (Martin 2017; Smith and Glauber 2020) and increasing agricultural total factor productivity (TFP) growth (Fuglie et al. 2020).

Trade liberalisation is expected to promote food security in several ways. Firstly, it fosters reconciliation of food deficits for net importers and surpluses for net exporters (World Bank 2012; Clapp 2014, 2015; Brooks and Matthews 2015). Secondly, trade acts as a food price volatility insulator during swings in production arising from seasonal variations and shocks (Gillson and Fouad 2015; Kalkuhl, von Braun, and Torero 2016). Thirdly, trade liberalisation enhances food security through the TFP growth channel. Trade liberalisation fosters TFP through technology transfer (Grossman and Helpman 1991), foreign direct investment (FDI) (Cavenaile, Roldan-Blanco, and Schmitz 2019), improved resource allocation (Sandoz 2017), and efficiency gains (Sunge and Ngepah 2020). In turn, growth in agricultural productivity leads to an increased supply of food at lower prices (Timmer 2002; Mozumdar 2012). It increases food production, creates employment, and increases

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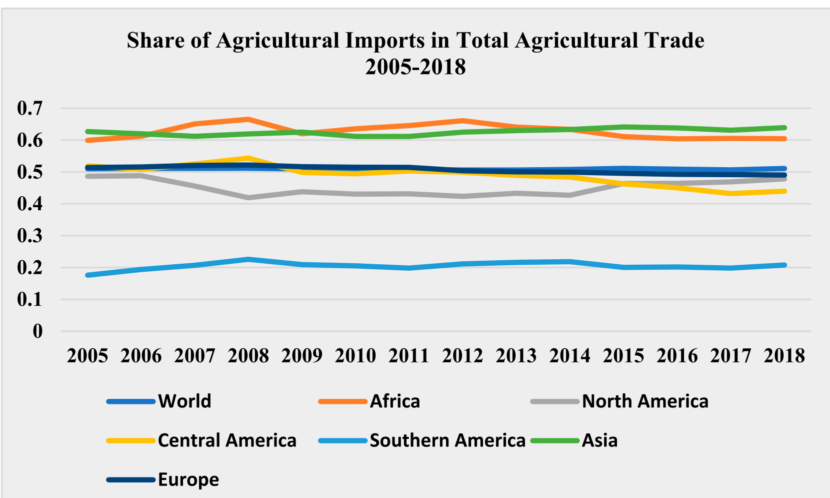
income in the agriculture sector (Clapp 2015). With higher incomes, food becomes more accessible (Mozumdar 2012; FAO 2016a).

The role of trade in reducing food security has been questioned. Generally, the assumptions of comparative advantage, core to the relationship, are unrealistic (Clapp 2015). As the United Nations Conference on Trade and Development (2009a) posits, modern food systems are monopolised and thrive on absolute rather than comparative advantage. Accordingly, the monopolies benefit from free trade instead of local farmers (McMichael 2013). FAO (2016a) also highlights that local availability may fall in net exporting countries. Also, producers in net importing countries may restrict production and rely on food imports. This will reduce food availability and incomes, respectively. Despite the possibility of trade liberalisation harming food security, there is a strong belief that freer trade should be promoted.

With increased emphasis on liberalising agricultural and food trade, Africa has recorded significant growth in food trade. Data from FAO (2020) show that growth in food trade, which averaged 3.75% between 1990 and 2004, more than doubled to an average of 8.84% between 1995 and 2018. The importance of trade to Africa's food security can be seen from the food trade balance. The region is generally a food importer. Statistics from FAO (2020) show that for the period 2005–2018, Africa is the region most dependent on agricultural imports for food requirements. As Figure 1 shows, the share of agricultural imports in total agricultural trade, averaging 62.75%, is higher than in any other region. The persistent food trade deficit is also illustrated in Figure 2. However, Africa is experiencing falling agricultural TFP growth. Over the periods 1991–2000, 2001–2010, and 2011–2014, annual agricultural TFP growth rates averaged 2.1%, 0.8% and 0.2% respectively (International Food Policy Research Institute (IFPRI) 2018).

Also, food insecurity in Africa is rising. Statistics from FAO, ECA, and AUC (2018, 2020) show that SDG 2 is not in sight for Africa. While the global food security situation is stable, the situation in Africa is deteriorating. The world prevalence of undernourishment, which was 8.9% in 2015, remained unchanged in 2019. In Asia, the prevalence has fallen from 10.1% in 2010 to 8.7% in 2014 and then 8.3% in 2019. However, after a marginal fall from 18.9% in 2010 to 17.6% in 2014, the prevalence rate in Africa has increased to 19.1% in 2019. The situation is acute in Sub-Saharan Africa, which has a prevalence rate of 22% in 2019. In 2018, of the 821 million undernourished people worldwide, 257 million were from Africa, of which 237 000 or 92.22% were from sub-Saharan Africa.



Source: Authors' illustration from FAOSTAT (2020)

Figure 1. Share of Agricultural Imports in Total Agricultural Trade: 2005–2018. Source: Authors' illustration from FAOSTAT (2020).

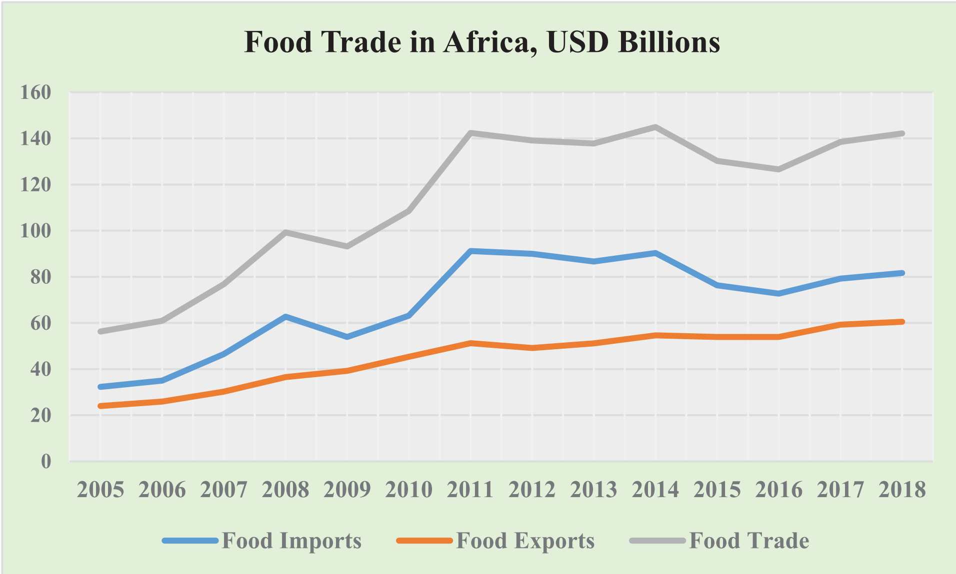


Figure 2. Share of Food Trade in Africa 2002–2018. Source: Authors' Illustration from UNCTAD Statistics (2020).

The paradox of increasing food trade, falling agricultural TFP growth, and deteriorating food insecurity has motivated the current study. We acknowledge existing studies, identify shortcomings, and provide a significant contribution. The first strand of studies provides evidence on the effects of domestic factors on food security. For instance, Aslam and Rasool (2014), Abegaz (2017), and Nkomoki, Bavorová, and Banout (2019) examined household food security. Others studied the effects of population (Hall et al. 2017), cash transfers (Burchi and Strupat 2018), non-farm income (Rahman and Mishra 2020), and climate change (Badolo and Somlanare 2013). However, evidence on the impact of international factors, particularly international trade, is still scant and evolving. The increasing and inevitable globalisation and the proliferation of multilateral, regional, and bilateral trade agreements have made international trade a vital determinant of every aspect of life, and food security is no exception.

Accordingly, the second strand, including Ivica (2016), Tinta et al. (2018), Bonuedi, Kamasa, and Opoku (2020), and Fusco, Colucci, and De Leo (2020), examines the impact of international trade on food security. These studies find that trade liberalisation improves food security. However, other studies found adverse effects of trade liberalisation on food security (Zhu 2016; Barlow et al. 2020). While these studies centred on universal trade liberalisation, other studies, as reviewed by McCorriston et al. (2013), narrowed the investigation to the impact of agricultural trade liberalisation. Another dimension of trade-related consequences on food security recognised non-tariff barriers (NTBs) as a key determinant. An analysis by Santeramo and Lamonaca (2019) revealed that the NTBs have heterogeneous effects on agric-food trade. One possibility is that the NTBs may act as a trade protection tool, which impedes agri-food trade and therefore increase food insecurity. Otherwise, NTBs can have a competition effect, which lessens market flaws. A notable area that has not received deserving research is the effect of domestic agriculture support.

The impact of such cannot be meaningfully derived from the trade openness measure. Yet existing evidence has not explored how the removal of trade-distorting agricultural support impacts food security. Two factors amplify the need to do so. Firstly, increasing calls for free trade have resulted in border protectionism, or lack of, being complicated while marginal gains from free trade are falling. Secondly, governments are faced with a dilemma to promote food self-sufficiency on one hand and competitiveness on the other. Hence, governments increasingly use domestic agriculture support more than border trade policy (Mittenzwei, Britz, and Wieck 2012). Nonetheless, how such variations affect food security is not empirically known.

To the best of our knowledge, this is the first attempt to analyse the impact of domestic agricultural support on food security. Accordingly, the paper's main goal is to examine the effects of agricultural trade in general and domestic agricultural support on food security in Africa. To do this, the current study takes advantage of recent data provided by FAO's Monitoring and Analysing Food and Agriculture Policies (MAFAP). The data measures the effect of incentives or distortions arising from domestic support using the nominal rate of protection (NRP)[1] for 14 African countries from 2005 to 2016.

The rest of the study proceeds as follows. Section 2 covers literature review. Section 3 presents materials and methods. Results are presented and discussed in section 4. Section 5 concludes by drawing policy recommendations from the findings.

2. Literature review

2.1 Theoretical literature

2.1.1 Food security: definition and dimensions

Food security is a complicated, multifaceted, and an evolving concept, and so is the definition. As early as 1993, Smith, Pointing, and Maxwell (1993) alleged over 200 definitions of food security. Napoli, Muro, and Mazziotta (2011) trace the definition to the 1943 Hot Springs Conference of Food and Agriculture. Food security was conceived to exist if there is a "secure, adequate and suitable supply of food for everyone" (p. 7). Then, the emphasis was on food availability and price stability at the national and international levels. However, the definition failed to recognise the stability, vulnerability, and nutritional facets of food security. Ever since, there has been an evolution of the food security concept. Maxwell (1996) highlighted three paradigm shifts. These are from (1) worldwide and country-wide focus to the household level, (2) food priority to livelihoods priority, and (3) objective to subjective perception.

The need for an inclusive classification led to the widely accepted and used definition by the United Nations (UN) during the 1996 World Food Summit. Food security is said to exist when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (IFPRI 2020).[2] In line with this definition, food security can be examined from four dimensions namely availability, accessibility, stability, and utilisation whose components and key indicators are shown in Table 1. According to Pinstrup-Andersen (2009), the inclusion of "safe and nutritious" and "food preferences" further broadened to consider nutritional components and access to preferred food.

Despite the UN definition being widely used, questions have been raised on whether the proposed definitions and measures captured the many facets of food security. For example, Santeramo (2015) and Caccavale and Giuffrida (2020) registered discomfort in confining the definition to independent dimensions. Santeramo (2015) argued that the different dimensions portray different information and are not equivalent. Yet Caccavale and Giuffrida (2020) deduced that all the food dimensions are equally crucial such that none can substitute others. As a result, the focus is shifting to coming up with composite indices that capture the various pillars of food security. The common ones are the Global Hunger Index (GHI) (Wiesmann 2006), the Global Food Security Index (GFSI) (Economist Intelligence Unit 2012), and the Ending Rural Hunger Index (ERHI) (Kharas et al. 2015). More recently, Caccavale and Giuffrida (2020) proposed the Proteus composite index.

Despite the increasing number of proposed indices, there is little consensus in defining some food security parameters. As Caccavale and Giuffrida (2020) argue, composite indices' major shortcoming is that the procedures and processes used are shrouded in subjectivity. Accordingly, in this paper, we adopt the 1996 World Food Summit definition and follow the food dimensions by FAO.

Table 1. Food security dimensions.

Food security dimension	Description	Key indicators
Availability	Food availability hinges on local production and/or trade (imports). Where local production (supply) fails to meet demand, food imports. Indicators:	(1) Average dietary energy supply adequacy (2) Average protein supply (g/cap/day) (3) Average supply of protein of animal origin (g/cap/day)
Accessibility	Food access requires people to have adequate physical and economic access, either through production; buying or any form of trade. Key to accessibility is productivity growth, economic growth (high income).	(1) Gross domestic product per capita (2) Number of moderately or severely food insecure people (3) Number of people undernourished (4) Number of severely food insecure people
Stability	The dimension is a realisation that food (in)security can change. Today one may be secure but insecure tomorrow. It considers vulnerability and risk arsing to variations in season and income as well as shocks like droughts, floods and pests etc.	(1) Cereal import dependency ratio (percent) (2) Per capita food production variability (3) Per capita food supply variability (kcal/cap/day) (4) Value of food imports in total merchandise exports
Utilisation	This is concerned with biological effects of food. It depends on the absorption of an adequate food diet, clean water and access to healthcare and sanitation. This determines the nutritional status of individuals.	(1) Percentage of population using at least basic drinking water services (2) Percentage of population using at least basic sanitation services (3) Percentage of children under 5 years of age who are stunted (4) Percentage of children under 5 years affected by wasting

Source: FAO (2020).

2.1.2 Trade liberalisation, total factor productivity, and food security

Trade is a means to reconcile food deficits for net importers and surpluses for net exporters (Brooks and Matthews 2015). Accordingly, trade enhances food security in several ways. Firstly, owing to disparities in natural resource endowments, the comparative advantage theory implies there exist importers and exporters. In that spirit, Smith and Glauber (2020) argue that according to World Bank (2012) and (Clapp 2014, 2015), an open trade setup will allow unrestricted movement of food from surplus to deficit countries, thereby enhancing food security. Also, without trade, net food importers face higher food prices while net exporters get lower food prices (Brooks and Matthews 2015). Consequently, the availability and accessibility of food are limited for net importers. On the other hand, lower incomes in exporting countries will be compromised, reducing food expenditure. Furthermore, seasonal variations imply variabilities in food supply. Open food trade ensures that global food output is more stable across seasons than domestic output, thereby cushioning the food supply variabilities.

Secondly, trade liberalisation enhances food security through the total factor productivity growth. Trade liberalisation fosters TFP in many ways. In the spirit of learning-by-doing (Arrow 1962), and exchange of technology embedded intermediate goods (Grossman and Helpman 1991), as well as a channel of foreign direct investment (FDI), and a conduit of technology transfer (Cavenaile, Roldan-Blanco, and Schmitz 2019) trade is expected to increase productivity in agriculture. Also, trade ignites competition which improves efficiency (Rijesh 2017; Elewa and Ezzat 2019). Furthermore, trade liberalisation improves resource allocation, allowing for gains from economies of scale

(Sandoz 2017). According to Timmer (2002) and Mozumdar (2012), growth in agricultural productivity leads to an increased supply of food at lower prices. Furthermore, agricultural productivity growth increases output, creates employment, and therefore increases income in the agriculture sector (Clapp 2015). Higher purchasing power makes food more accessible (Mozumdar 2012; FAO 2016a).

Thirdly, trade acts as a food price volatility insulator. Food price shocks can be severe with closed trade, particularly vulnerable populations (Kalkuhl, von Braun, and Torero 2016). Swings in production, arising due to seasonal variations, droughts, and other natural conditions may increase food deficits and therefore increase food prices. In this case, trade acts as a transmission belt allowing supply to increase in affected countries which dampens prices (Gillson and Fouad 2015).

The conventional wisdom that liberalising trade provides various opportunities favouring food security has been challenged. Firstly, the conclusion is based on the comparative advantage theory, whose assumptions are not perfect. As a result, the theory limits trade opportunities on food security (Clapp 2015). In particular, the structure of global agri-food value chains tends to dampen food security gains. According to the United Nations Conference on Trade and Development (UNCTAD) (2009a), modern food systems are directed and dominated by few transitional and influential organisations. Given the monopoly tendencies, such organisations can be highly mobile, thriving on absolute rather than comparative advantage. Also, instead of farmers in given economies benefiting from increased income and profits, the transitional organisations will do so (McMichael 2013).

Another red flag on the food-enhancing role of trade stems from the food sovereignty and self-sufficiency concepts[3] at national levels. If anything, the 2008 global food prices hike re-invented this thought. The crisis was more severe on net importing countries. This exposed their reliance on food imports and switched the philosophy back to self-sufficiency (Wittman, Desmaris, and Wiebe 2010). According to supporters of the food sovereignty view, interpretations of food security neglected where the food should come from nor how it is produced (Fairbairn 2010). FAO (2016a) also highlights how trade may cause food insecurity in net exporting and importing countries. Local availability of staples may fall in net exporting countries. This happens as higher prices in deficit markets can attract exporters. Accordingly, they supply more outside at the expense of the local market. Similarly, suppliers in net importing countries may restrict production and rely on imports. This sacrifices the multiplier effects agricultural production has on the domestic economy. In the end, employment, incomes, and therefore food expenditure falls.

2.1.3 Domestic agriculture support and food security

In addition to border trade openness, and in line with the AoA, reducing domestic trade-distorting market interventions is expected to improve food security. Reducing such market interventions, including agricultural taxes and subsidies, limitations on food exports, and manipulation of state marketing boards create favourable production and price decisions (Anderson, Martin, and van der Mensbrugghe 2006). According to Lamy (2013), the market interventions significantly increase protection in agriculture. This, in turn, compromises consumers' ability to access enough food and therefore exposes them to food insecurity (Lamy 2013). It follows that decreasing levels of protection can increase national incomes (Martin 2017). Consequently, a decrease in food production costs and increasing returns for poor farmers in net food-exporting countries will improve nutrition. As Basurto, Dupas, and Robinson (2020) elaborate, many developing countries subsidise consumers with the poor in mind. However, the intervention frequently reduces farmers' income, who are usually poorer than most urban consumers who benefit from such interventions. Furthermore, Glauber (2018) argues that farm support given by developed countries may adversely affect rural development in developing countries, thereby increasing malnutritional and food insecurity.

Moreover, price and trade-distorting agriculture support may eliminate the comparative advantage of countries endowed with agricultural resources. In situations where there are significant distortions in agriculture, trade in agricultural commodities does not reflect comparative advantage but the distortions (UNCTAD 2009b). The distorted prices are pushed above or kept below-market prices.

This makes food prices high or reduces farm incomes (Kostadinov 2013). Consequently, food access and availability are affected negatively.

Although government intervention may be associated with distortions, there are known benefits. For example, the need to continually deepen competition may justify government support. The social network theory (Burt 2000) and the resource-based view theory (Bennett and Robson 2003) suggest that government creates strong external ties which allow access to rare and inimitable resources. Also, producers may benefit from government R & D support and networking with foreign partners (Songling et al. 2018). Such support enhances competition. Increased competition by local farmers may increase efficiency in food production (Kostadinov 2013) and therefore increase food security. Also, increasing population, growing urbanisation, and increased unemployment provide a rationale for market interventions.

2.2 Empirical literature

Evidence on food security determinants is quite extensive. Some studies have looked at household determinants (Aslam and Rasool 2014; Abegaz 2017; Nkomoki, Bavorová, and Banout 2019), while others focused on factors like population (Hall et al. 2017), cash transfers (Burchi and Strupat 2018), non-farm income (Rahman and Mishra 2020), and climate change (Badolo and Somlanare 2013). However, evidence of the impact of external factors, particularly international trade, is still scant and evolving. The proliferation of multilateral, regional, and bilateral trade agreements has made international trade a vital determinant of every aspect of life, and food security is no exception. The few studies in this regard are based on the effect of aggregate trade and generally provide evidence that trade liberalisation favours food security.

Bonuedi, Kamasa, and Opoku (2020) examined the impact of trade facilitation on food security using first-difference instrumental variable estimation of panel data from 45 African countries from 2006 to 2015. They find that poor trade facilitation, notably higher documentation requirements, is detrimental to food security in Africa. Another dimension was provided by Tinta et al. (2018). They distinguished the impact between regional trade (integration) and international trade in ECOWAS. Using fixed-effects panel data analysis, the study found that international trade openness has a favourable and significant impact on food security. However, regional trade was found to have a larger, favourable, but statistically insignificant effect on food security. They attributed the non-significance to the faintness of trade in the region, a position previously highlighted by Ivica (2016).

A more recent study by Fusco, Colucci, and De Leo (2020) examined the impact of trade liberalisation on food security in the European Union. The study regressed two aspects of food security (average protein supply and average dietary energy supply adequacy) against three measures of trade liberalisation (trade openness, tariffs, and globalisation). Using a generalised-methods-of-moments (GMM) estimation technique, results suggested that trade liberalisation had a net-positive and statistically significant effect on food security. Using a similar estimation technique to control for heterogeneity and endogeneity, Dithmer and Abdulai (2017) also examined the impact of trade openness, agricultural productivity, and economic growth on food security. The study concluded that these variables have favourable food security effects.

Barlow et al. (2020) provided evidence that the effect of trade policy on food security depends on a country's level of income. Their evidence is based on observational analysis, particularly weighted algorithmic methods and logistic regressions on a large sample of 460,102 households drawn from 132 countries over the period 2014–2017. Results indicated that a one-unit increase in liberal trade caused a 0.07% fall in the probability of moderate food insecurity in high-income countries. For low-income countries, the same unit increase in liberal trade increased the chances of moderate food insecurity by 0.35%. Evidence of the negative impact of liberalised trade on food security has also been provided by Zhu (2016). Drawing an inference from an auto-regressive distributed lag (ARDL) estimation for China, the study concluded that trade has increased China's import dependence and, therefore negatively affected its food security position.

Also, other studies examined the impact of discriminatory trade liberalisation arising from regional trade agreements (RTAs). Herath, Cao, and Chen (2014) employed the FGLS and PSCE panel estimators for the Association of Southeast Asian Nations for the period 1980–2009. Results confirmed that after the formulation of the RTA, member countries' per-capita daily dietary energy supply increased. Another analysis on Common Market for East and Southern Africa (COMESA) by Wanjiku et al. (2012) finds that liberalised cross-border trade improves food security by dampening food price volatility. This conclusion was strongly supported by Morrison (2013) for Eastern and Southern Africa regions. However, recent evidence by Pasara and Diko (2020) warns that the impact of regionalism depends on the level of openness before joining a trade agreement. Their conclusion is based on a simulation model assessing the likely effects of the AfCFTA on trade in cereals in the Southern African Development Community (SADC) countries. Using the World Integrated Trade Solution, Software for Market Analysis and Restrictions on Trade (WITS-SMART), results indicated diminishing marginal gains; countries not part of a free trade agreement (FTA) are expected to benefit more than previously open ones.

The evidence reviewed thus far on trade, and food security has one common aspect, which questions their conclusions. The examination of trade is against aggregate/economy-wide trade liberalisation. Concluding that trade liberalisation positively affects food security may be misleading. For instance, this ignores the reality that agriculture and food commodities trade is different from other sectors. If non-agriculture commodities dominate a country's trade, a fallacy that trade boosts food security is likely. Relatively few studies have recognised this critical distinction. A review of such investigations by McCorriston et al. (2013) shows that evidence is marginally favouring the positive effects of agricultural trade liberalisation. Moreso, a thorough examination of agricultural trade liberalisation impacts should be in the spirit of the AoA. Unlike conventional trade agreements, the AoA is anchored on three pillars: market access, export competition, and domestic agriculture support. In one way or another, the first two pillars are covered under trade openness. However, domestic agriculture support is a distinct aspect whose impact cannot be meaningfully derived from trade openness measures. Yet existing evidence has not explored how the removal of trade-distorting agricultural support impacts food security. Two factors amplify the need to do so; (1) increasing calls for free trade has resulted in border protectionism, or lack of, being complicated while marginal gains from free trade are falling, (2) governments are faced with a dilemma to promote food self-sufficiency on the one hand and competitiveness on the other. Accordingly, governments are increasingly using variations in domestic agriculture support more than border trade policy.

Nonetheless, how such variations affect food security is not empirically known. The current study takes advantage of recent data provided by FAOs Monitoring and Analysing Food and Agriculture Policies (MAFAP) to fill this gap. The data measures the effect of incentives or distortions arising from domestic support using the nominal rate of protection (NRP) for 14 African countries from 2005 to 2016.

3. Materials and methods

We use panel data from 13 African countries[4] for the period 2005–2016 for analysis. Food security is proxied by two measures: daily per-capita-dietary-energy supply and undernourishment prevalence. They represent two main pillars of food security: food availability and accessibility. Key explanatory variables under investigation are agricultural TFP growth, food trade openness, and nominal rate of protection. Following diagnostic tests on cross-sectional dependence, serial autocorrelation, and heteroskedasticity, we employed the Panel Corrected Standard Error (PCSE) estimator for analysis.

3.1 Theoretical framework.

The theoretical origin of our model is inspired by Chang and Zepeda (2001), Dithmer and Abdulai (2017), and Fusco, Colucci, and De Leo (2020), where food security is affected by a group of variables which we classify into agricultural specific, demographic, and macroeconomic:

$$FS_{it} = \alpha + \gamma AGR_{it} + \delta ECC_{it} + \epsilon_{it} \tag{1}$$

Where *FS* is food security. For robustness, we use two measures of food security, daily per-capita dietary supply, and undernourishment prevalence. These are proxies of the two main components of food security, food availability, and access respectively. *AGR* is a vector of agriculture sector-related variables, and *ECC* is a vector of economic variables. Subscripts i, $i = 1, \ldots.., N$ and t, $t = 1, \ldots\ldots, T$ are cross-sections and time periods respectively. γ and δ are parameters to be estimated. Lastly, ϵ is the error term. Our variables of interest are in the agriculture sector.

Firstly, we consider the effect of agricultural productivity on food security. Increasing agricultural productivity growth is primarily considered an avenue to increase food supply. Increasing productivity is expected to increase yield in net importing countries which reduces the gap between consumption and production. More so, we examine the impact of food trade openness on food security.

Unlike other studies, we include the effect of domestic agriculture support on food security. In the spirit of the AoA, countries are supposed to reduce distortions in agriculture. The notion behind this is that fewer distortions eliminate farm inefficiencies. This leads to higher agriculture output and increased food availability, thereby positively impacting food security. With agriculture sector variables and in natural logarithms, the model becomes:

$$\log FS_{it} = \alpha + \gamma_1 lgTFP_{it} + \gamma_2 lgFDTOP_{it} + \gamma_3 NRPFS_{it} + \delta \sum ECC_{it} + \epsilon_{it} \tag{2}$$

Where *TFP* is agricultural total factor productivity growth, *FDTOP* is food trade openness and *NRPFS* is the aggregate nominal rate of protection towards food security commodities. We also add demographic and economic variables to (2). Firstly, population growth is expected to be the leading threat to food security globally (Hall et al. 2017). FAO (2017) project that by 2050, the world population will be close to 10 billion. The threat is grave in Africa, where its global proportion is projected to increase from 17% in 2020 to 26% in 2050. Accordingly, we include population as a determinant of food security. Also, the role of economic growth on food security does not need emphasis. Furthermore, following (Gazdar and Mallah 2013; Woertz, Soler, and Farrés 2014), we also control for the effect of inflation, in particular food inflation. This gives:

$$\log FS_{it} = \alpha + \gamma_1 lgTFP_{it} + \gamma_2 lgFDTOP_{it} + \gamma_3 NRP_{it} + \delta_1 lgGDP\_capita_{it} + \delta_2 lgPOPN_{it} + \delta_3 FDINFL_{it} + \epsilon_{it} \tag{3}$$

Where *GDP_capita* is gross domestic product per capita, *POPN* is population and *FDINFL* is food inflation. Lastly, to disentangle the impact of components of trade, we disaggregate food trade openness into two; export (*XPOP*) and imports (*MPOP*). This gives:

$$\log FS_{it} = \alpha + \gamma_1 lgTFP_{it} + \gamma_2 lgXPOP_{it} + \gamma_3 NRP_{it} + \delta_1 lgGDP\_capita_{it} + \delta_2 lgPOPN_{it} + \delta_3 FDINFL_{it} + \epsilon_{it} \tag{3$'$}$$

$$\log FS_{it} = \alpha + \gamma_1 lgTFP_{it} + \gamma_2 lgMPOP_{it} + \gamma_3 NRP_{it} + \delta_1 lgGDP\_capita_{it} + \delta_2 lgPOPN_{it} + \delta_3 FDINFL_{it} + \epsilon_{it} \tag{3$''$}$$

3.2 Data: description and sources

Data descriptions and sources are presented in Table 2. We focus on the dependent variables and key independent variables. The average prevalence of undernourishment for the 12 countries is 18.24, with a coefficient of variation of 0.51. The rate is slightly below that recorded for the whole of 2019 in Africa (19.1%). However, it is more than twice the world prevalence of 8.9% in 2019, implying high rates of food insecurity. Although the rate has been falling over the period under study, a low coefficient of variation means that the gains have been very slim. As for food availability, the dietary energy supply averaged 2422.82 kilocalories per capita. This is below world levels (2767.78) as well as that of other developing regions like Asia (2662.78) and Latin America (2932.89). Again, the coefficient of variation (0.17) suggests that the improvements that have been recorded in the last decades are marginal.

Table 2. Data description and sources.

Variable	Description	Food Availability	Food Accessibility	Source(s)
Dietary Energy Supply Adequacy (DESA)	An estimate of the amount of calories from foods available for human consumption. Measured in daily kilo calories per day (kcal/cap/day)	2422.82* (281.66) [0.17]		FAOSTAT http://www.fao.org/faostat/en/#data/FS
Prevalence of Undernourishment	The probability that a randomly selected individual from the population consumes an amount of calories that is insufficient to cover her/his energy requirement for an active and healthy life.		18.24* (9.21) [0.51]	FAOSTAT http://www.fao.org/faostat/en/#data/FS
Total Factor Productivity Index	Output growth minus Input growth. Output is defined as FAO gross agricultural output. Input growth is the weighted-average growth in quality-adjusted land, labour, machinery power, livestock capital, synthetic NPK fertilisers, and animal feed, where weights are input (factor) cost shares.	107.02* (16.484) [0.15]	109.38* (14.47) [0.13]	United States Department of Agriculture (USDA), Economic Research Service. Using FAO and ILO data. https://www.ers.usda.gov/data-products/international-agricultural-productivity/
Total Food Trade Openness	The ratio of food trade over a country's agriculture GDP	0.35* (0.41) [1.17]	0.35* (0.42) [1.20]	Computed from FAO Agriculture Trade and Agriculture Valued Added Output
Nominal Rate of Protection on Food Security Commodities	Measure of the effect (in relative terms) of domestic market and trade policies and overall market performance on prices received by agents in the food security crops value chain. It is calculated as the ratio between the observed price gap and reference price measured at farm gate.	0.09* (0.42) [4.78]	0.09* (0.43) [4.77]	FAO and MAFAP Data http://www.fao.org/in-action/mafap/country-analysis/en/
Gross Domestic Product (GDP/per capita)	Gross domestic product per capita, PPP, dissemination (constant 2011 international $)	847.48* (523.26) [0.617]	868.60* (539.14) [0.62]	FAOSTAT http://www.fao.org/faostat/en/#data/FS
Food Price Inflation	Food Price inflation, computed from monthly food inflation	0.094* (0.094) [1.01]	0.09* (0.10) [1.04]	FAOSTAT http://www.fao.org/faostat/en/#data/PP
Population	The annual population growth rate	41,700,000* (38,900,000) [1.07]	43,300,000* (38,900,000) [1.11]	World Bank Development Indicators

*Denotes the mean values and in parenthesis ( ) are variable standard deviations while in brackets [ ] are coefficient of variations.

Statistics for explanatory variables are almost the same for food availability and accessibility. This is because the number of countries is almost the same. Here we highlight the variations for the food availability model. Food trade openness averaged 0.35 with a coefficient of variation of 1.17, which is only second to the nominal rate of protection (4.78). This indicates that 35% of food consumed was from trade, of which 20% are imports, and 15% are exports. More import openness signifies the importance of food imports in closing domestic food deficits, hence enhancing availability. The nominal rate of protection averaged 0.09 and has the highest volatility, as measured by the coefficient of variation of 4.78. A positive mean implies that food security commodity producers have received prices 9% higher than government support free levels. This is a reasonably low value. However, the high variation shows that governments often alter the incentives they give to farmers as part of their food security policies. Total factor productivity index averaged 107.02 with a low variation of 0.15. This shows that on average, agricultural TFP growth has been increasing by 7% from the base year (2005). The index for the sample countries is higher than that for Africa (101.66) but lower for world (112.83) indices.

3.3 Econometric estimation

We use the Panel Corrected Standard Error (PCSE) for analysis. The choice for the estimator has been made easy by its ability to provide both consistency and efficiency when panel data, as is often, is confronted with complex error terms. Usually, panel data models are subject to cross-sectional dependence, serial, and heteroskedasticity problems (De Hoyos and Sarafidis 2006; Reed and Ye 2011; Sarafidis and Wansbeek 2012; Bai, Cho, and Liao 2020). Various Monte-Carlo simulations have shown that in the presence of these three problems, conventional panel data estimators, the fixed and random effects, do not provide consistent and efficient estimates.

3.3.1 Cross-sectional dependence

Cross-sectional dependence is usually a result of spill-over/spatial effects, or common unobservable effects arising to interfaces within socio-economic systems (Chudik and Pesaran 2013). In agriculture, dependence across sectional units can occur due to common seasonal variations, increasing trade policies and agreements harmonisation, and global commodity price fluctuations. According to Phillips and Sul (2007), the conventional panel data estimators such as fixed effects and random effects produce inconsistent coefficients, which may mislead inference. The inconsistency is exacerbated if there is a correlation between the unobserved effects and the observed independent variables (Kouwoaye 2019). Therefore, it is important to test for cross-sectional dependence before estimation. We used Pesaran's (2004) CD test, which is an improvement on Breusch and Pagan's (1980) LM test.

3.3.2 Serial autocorrelation

According to Baltagi et al. (2008), serial autocorrelation occurs because unobserved shocks to relationships are likely to stay for more than a single period. The effect of ignoring serial correlation in linear panel-data models is that the standard errors are biased, resulting in less efficient results. We use the Wooldridge (2002) test to check for serial autocorrelation before estimation. According to Drukker (2003), the strength of the test is that it can easily be applied under general conditions with good size and power properties.

3.3.3 Heteroskedasticity

Key to the classical linear regression model (CLRM) is the assumption of the homoscedasticity-constant variance of error terms. Nevertheless, for panel data, this assumption is restrictive. According to Feng et al. (2020), conditional variance usually may arise due to varying sizes of cross-sectional units. In this case, if the error terms are erroneously specified as homoscedastic, then the system produces inefficient least squares and inconsistent estimates. Accordingly, testing for the presence of heteroskedasticity or the use of heteroskedastic-robust estimators is encouraged in panel data analysis.

3.3.4 Panel Corrected Standard Error estimator

The results from the tests on contemporaneous dependence and serial autocorrelation strongly confirmed their presence. The chosen estimator is, by default, robust to heteroskedasticity. Therefore, we didn't test for its presence. Accordingly, either the Feasible Generalised Least Squares (FGLS) and PCSE estimators, both robust to the three problems, can be used (Bai, Cho, and Liao 2020). These estimators have more common attributes, but the few differences are worth noting. The FGLS estimator, developed by Parks (1967), has issues that reduce its efficiency. The estimator is known for severely underestimating standard errors in finite samples (Reed and Ye 2011). Also, it can only be used when the number of periods, T, is greater than the number of cross-sections, N. A thorough critique of the FGLS estimator by Beck and Katz (1995) claimed several flaws. The FGLS was found to produce intensely imprecise coefficient standard errors. They proposed the PCSE estimator as an alternative, suggesting that it produces accurate errors. Comparing the two, they concluded that the advantage of the FGLS over PCSE is relatively trivial unless T doubles N (Reed and Ye 2011).

Following an ensuing debate, Reed and Ye (2011) used the Monte-Carlo approach to compare the two estimators. They conclude that whilst there is no rule of thumb when choosing between the two, huge differences in the performances of the estimators exist. Also, they give scenarios in which each estimator can be the best. Following Beck and Katz's (1995) conclusion that the FGLS gives only slight efficiency when T at least doubles N, we use the PCSE. Besides, our data structure in which $N \geq T$ suits well the PCSE estimator. Also, for the food availability model, N is greater than T thereby ruling the FGLS estimator out.

The PCSE is derived from the data generating process (DGP) for the FGLS estimator as introduced by Parks (1967). It is expressed as follows:

$$y_{it} = \beta_0 + X_{it}\beta + \varepsilon_{it} \tag{4}$$

Where y_{it} and X_{it} are $Tx1$ vectors of dependent and independent variables for the i^{th} unit, $i = 1, 2 \ldots\ldots N$, over the period $t = 1,\ 2,\ \ldots\ldots T$; β and ε_{it} are vectors of parameters and error terms to be estimated and $\varepsilon_{it} \sim N(0, \Omega_{NT})$. We follow the approach by Parks (1967), Beck and Katz (1995), and Reed and Ye (2011) by modelling the structure of Ω_{NT} so that it controls for cross-sectional dependence, first-order correlation, and group-wise heteroskedasticity. The specification is as follows:

$$\Omega_{NT} = \sum \otimes \prod \tag{5}$$

Where $\sum \begin{bmatrix} \sigma_{\varepsilon,11} & \sigma_{\varepsilon,12}\cdots & \sigma_{\varepsilon,1N} \\ \sigma_{\varepsilon,21} & \sigma_{\varepsilon,2}\cdots & \sigma_{\varepsilon,2N} \\ \vdots & \vdots & \vdots \\ \sigma_{\varepsilon,N1} & \sigma_{\varepsilon,N2}\cdots & \sigma_{\varepsilon,NN} \end{bmatrix}$; $\prod = \begin{bmatrix} 1 & \rho & \rho^2 & . & . & \rho^{T-1} \\ \rho & 1 & \rho & . & . & \rho^{T-2} \\ \rho^2 & \rho & 1 & . & . & \rho^{T-3} \\ . & . & & . & . & . \\ . & . & . & . & . & . \\ \rho^{T-1} & \rho^{T-2} & \rho^{T-3} & . & . & 1 \end{bmatrix}$ and $\varepsilon_{it} = \rho\varepsilon_{i,t-1+u_{it}}$.

To get the parameter estimates, $\hat{\beta}$, the FGLS estimator employs the formula:

$$\hat{\beta} = (X'\hat{\Omega}^{-1}X)^{-1}X'\hat{\Omega}^{-1}yVar(\hat{\beta}) = (X'\hat{\Omega}^{-1}X)^{-1} \tag{6}$$

To obtain PCSE estimates, Beck and Katz (1995) used a two-step approach using the formula:

$$\hat{\beta} = (\tilde{X}'X')^{-1}\tilde{X}'\tilde{y}Var(\hat{\beta}) = (\tilde{X}'X')^{-1}\left(\tilde{X}'\widehat{\sum}\tilde{X}\right)(\tilde{X}'X')^{-1} \tag{7}$$

Where $\tilde{X}$ and $\tilde{y}$ denotes that Prais-transformed vector of regressors and dependent variables and $\widehat{\sum}$ is an estimate of $\sum$ in (5).

4. Econometric results

4.1 Cross-sectional dependence, serial autocorrelation

The Pesaran (2004) cross-sectional dependence (CD) test results are shown in Table 3. In all but one variable-food inflation- the null hypothesis of cross-sectional independence is strongly rejected at a 1% significance level. This suggests that a shock in any of these variables affects other countries. This reflects an anticipated feature of panel data analysis in an increasingly globalising world. The growing integration of agriculture and food systems in Africa has seen some convergence in policy frameworks. Accordingly, countries have entered into international, regional, and bilateral agreements covering agriculture individually and as groups. As such, strong interdependencies among the countries are justifiable. The existence of cross-sectional dependence validates our adaption of the PCSE estimation of the models. The estimators give standard errors that are robust to the cross-sectional dependence.

Wooldridge's serial-autocorrelation test results are shown in Table 4, panel C. Across all the models, the null hypothesis of serial auto-correlation independence is rejected at a 1% level of significance. This implies that the assumption of constant serial correlation in the individual effects does not hold. The existence of autocorrelation problem is strongly linked to cross-sectional dependence above. According to Bai, Cho, and Liao (2020), serial autocorrelation arises when the individual or the group level disturbances are serially correlated.

4.2 Variables of interest

The results are shown in Table 4. Results are presented in three panels. In panel A, the dependent variable is the log of dietary energy supply. In B, it's the log of undernourishment prevalence. Under each panel, three models are estimated to capture impacts by the composition of trade. The main model is in column 1, where total food trade openness estimates are shown. In models 2 and 3, estimates with disaggregated trade openness, exports, and imports are presented. Panel C presents results from diagnostic tests.

Estimation parameters for TFP growth have the expected signs for both food security measures. For the main model, (A1) under dietary energy supply adequacy (DESA), the parameter is positive and highly significant at 1%. At 0.109, we deduce that a 1% increase in agricultural TFP growth has been responsible for an approximately 0.11% increase in DESA in the sample countries. In panel B1, the coefficient (0.23) is

Table 3. Cross-sectional dependence.

	Dietary adequacy supply food availability				Undernourishment prevalence food access			
Variable	CD-test	*p*-value	corr	abs(corr)	CD-test	*p*-value	corr	abs(corr)
lgdes	8.930	0.000	0.295	0.628	8.770	0.000	0.318	0.575
lgtfpi	3.880	0.000	0.128	0.497	6.910	0.000	0.247	0.477
lgagtdop	12.900	0.000	0.424	0.484	10.990	0.000	0.392	0.463
lgagxpop	8.910	0.000	0.291	0.469	7.110	0.000	0.253	0.452
lgagmpop	13.780	0.000	0.450	0.479	11.810	0.000	0.420	0.454
nrpfs	−0.150	0.880	−0.006	0.297	−0.580	0.565	−0.022	0.314
lgycpta	27.760	0.000	0.913	0.913	25.310	0.000	0.912	0.912
fdinfl	8.570	0.000	0.282	0.374	9.290	0.000	0.335	0.411
population	30.59	0.000	1.000	1.000	28.14	0.000	1.000	1.000

Table 4. Panel Corrected Standard Error (PCSE) estimation results.

	Panel A-Food Availability Dietary Energy Supply Adequacy (DESA)			Panel B-Food Access Undernourishment		
	(1)	(2)	(3)	(1)	(2)	(3)
Variables	Total openness	Export openness	Import openness	Total openness	Export openness	Import openness
lgTFPI	0.109*** (0.018)	0.106 *** (0.018)	0.104*** (0.016)	−0.230*** (0.137)	−0.210* (0.121)	−0.193 (0.135)
lgFoodTrade	0.015*** (0.005)			−0.054*** (0.025)		
lgExport		0.011*** (0.004)			−0.064*** (0.021)	
lgImports			0.016*** (0.006)			−0.020 (0.019)
NRP_FoodSecurity	−0.034*** (0.009)	−0.040*** (0.010)	−0.035*** (0.008)	0.226*** (0.062)	0.146*** (0.052)	0.234*** (0.063)
lgGDP_capita	0.133*** (0.011)	0.138*** (0.011)	0.144*** (0.011)	−0.687*** (0.040)	−0.658*** (0.046)	−0.723*** (0.039)
Food Inflation	−0.014 (0.018)	−0.015 (0.018)	−0.013 (0.018)	−0.114 (0.110)	−0.080 (0.095)	−0.114 (0.108)
lgPopulation	−0.023*** (0.007)	−0.023** (0.007)	−0.021** (0.006)	0.171*** (0.040)	0.087*** (0.043)	0.178*** (0.040)
CONSTANT	6.721*** (0.176)	6.736*** (0.191)	6.652*** (0.167)	5.739*** (0.978)	6.829*** (0.924)	5.549*** (0.947)
R-Squared	0.9998	0.9999	0.9998	0.9690	0.9756	0.9673
Observations	155	155	155	142	143	142
Wald χ^2 test	229.28*** [0.000]	318.48*** [0.000]	256.05*** [0.000]	1025.17*** [0.000]	364.25*** [0.000]	864.35*** [0.000]
Panel C-diagnostics						
C-D Test	✓	✓	✓	✓	✓	✓
Wooldridge Test	36.26*** [0.000]	31.51 *** [0.000]	29.457*** [0.000]	341.99*** [0.000]	350.38*** [0.000]	369.81*** [0.000]

***, **, and * denotes 1%, 5%, and 10% level of significance respectively. In parenthesis ( ) are standard errors and in brackets [ ] are probabilities for diagnostic tests.

now bigger but negative while it retains high significance. This suggests that a 1% increase in agricultural TFP growth reduces undernourishment prevalence by 0.23%. Both coefficients confirm, as expected, that increasing agricultural TFP growth plays a crucial role in reducing food insecurity in Africa. As literature shows, this happens in several ways. Higher TFP growth increases agricultural labour incomes (Clapp 2015), increases food availability, and lowers food prices (FAO 2016a), and provides macro-economic multiplier effects through forward and backward connections (Mozumdar 2012).

The strong and significant impact of agricultural TFP growth provides an impetus towards reducing food insecurity. In recent decades, food security gains in Africa have been driven by input expansion. The Global Harvest Initiative (2017) projections indicate that only 8% of Africa's food demand by 2030 will be met through agricultural TFP growth. However, our results suggest that this can be changed. Accordingly, increased support in agricultural R&D and innovation systems should be given priority.

Regarding food trade openness, estimates are favourable for both food availability and access. The coefficient (0.015) is positive and highly statistically significant in the former. This entails that a 1% increase in food trade openness accounts for a 0.015% increase in dietary energy supply adequacy. In the former, the coefficient (−0.054) tells that the prevalence of undernourishment falls by 0.05% following an increase in openness by 1%. Our findings echo conclusions by Brooks and Matthews (2015) that trade has a positive net effect on food security. The results support the logic that increased openness to trade in food insulates domestic citizens from localised and transitory food supply oscillations (World Bank 2015). Also, high food trade openness is key in mitigating the negative effects of food price volatility. Thanks to the free movement of food, global food output for given commodities is steadier than local output. This allows countries to import more food during needy times and export during surplus, thereby ensuring food security stability.

When trade openness is disaggregated into exports and imports, we observe some variation in line with self-sufficiency and import dependency effects on undernourishment prevalence. While both components of trade have favourable outcomes, the impact of exports is not only higher but significant. For model B2, export food trade openness has a parameter of −0.064, which is significant at 1%. However, in B3, import food trade openness has a lower parameter of −0.020, which is statistically insignificant. This variation speaks to the composition of food trade in the sample countries. The average food trade balance for countries in panel B is -USD339 million. The countries are, on average net food importers. While imports would insulate domestic food supply volatilities, the food security gains, unlike those from exports, do not come with local multiplier effects. Along the value chain, exported food generates employment and increases earnings in primary and secondary agricultural and food sectors. Whereas for imported food, the jobs and earnings effects are weak. According to FAO (2016a), producers in net food-importing countries may restrain production at the expense of agricultural economic gains in rural areas. This implies that food security resulting from self-sufficiency is more desirable than from import dependency.

Turning to the reduction of trade-distorting agricultural support, results lament the distortionary effects of domestic agriculture support. The nominal rates of protection on the food security coefficients for both food availability and accessibility are statistically significant at the 1% level. A negative coefficient under food availability of −0.034 implies that a one-unit reduction in domestic agricultural incentives beyond distortion-free levels increases dietary energy supply by 3.4%. Given an average of 2423 kcal/capita/day, this translates to an increase of approximately 82.38-kilocalories/capita per day. Under food accessibility, the coefficient is large and positive (0.226). Intuitively, this tells that an increase in government support to farmers over and above market-determined levels tends to increase the prevalence of undernourishment by 22.6%. With undernourishment prevalence averaging 18.24%, it may increase by 4.12%.

The findings portray a complex puzzle developing countries always face. On the one hand, governments are understandably forced to support farmers heavily in recognition of agriculture's socio-economic and political importance. For instance, the African Union (UN) Maputo Declaration of 2003 compelled members to allocate at least 10% of government expenditure to agriculture and rural development (New Partnership for Africa's Development (NEPAD) 2003). Accordingly, FAO (2017) reports Africa and Asia having the highest central budget expenditure to agriculture. On the other, the support given to agriculture can easily be distortionary.

It can be deduced that it is not the quantity of the agriculture support given to farmers, but how it is used. The agriculture support given to farmers in developing countries, such as price support, input subsidies, and direct transfers, is likely to be amber expenditures that choke agricultural productivity and food security gains. According to Pernechele, Balié, and Ghins (2018), most agricultural spending in Africa is in the form of direct transfer to producers deemed trade distortionary, yet R&D receives only around 7%. Whereas in the OECD countries, USD 76 billion, or 17%, of support to agriculture has been spend on investments in agricultural innovation, biosecurity, and infrastructure (OECD 2021). Earlier on, Josling (2015) noted that most agriculture support in developed countries favours Green Box expenditure. In contrast, Africa's is biased towards Amber Box. Our findings provide hope to Africa's agriculture. An important issue that emerges from these findings is that food security can be enhanced by switching government expenditure in agriculture to productive votes like R&D, innovation, and infrastructure. We argue that post the COVID-19 pandemic, agricultural R&D and innovation should be central to government agrarian support programmes.

The results show that the key explanatory variables provide significant and favourable food security gains. Which one is more influential in enhancing food security, and for which measure? To judge effectively, we can't rely on the absolute coefficients, given that the explanatory variables are measured in different units. Accordingly, we construct standardised coefficients for the three variables, as shown in Table 5.

First, we compare the impact of agricultural TFP growth and total food trade openness for food availability. By looking at standard coefficients of 0.109 and 0.015, the former seems to have a seven times bigger impact than the latter. However, standardised coefficients of 0.150 and 0.108 show that agricultural TFP growth has a higher marginal impact. The coefficients portray that a one-standard-deviation increase in agricultural TFP growth and food trade openness causes a 0.150 and 0.108 standard deviation increase in dietary energy supply. On this basis, agricultural TFP growth's impact is only 1.39 times bigger than total food trade openness. Secondly, we clear the illusion between the two measures of food security. The food trade openness unstandardised coefficients are 0.015 and −0.054 for food availability and access. The impression here is that trade openness is more effective in reducing undernourishment than it increases dietary energy supply.

However, the standardised coefficients 0.108 and −0.079 indicate that trade openness increases dietary energy supply 1.37 times more than it reduces undernourishment prevalence. Also, the impact of reducing the nominal rate of protection has been magnified by 6.11 times in favour of reducing undernourishment. However, by comparing the standardised coefficients, the impact is just 1.37 times bigger. From standardised coefficients, we conclude that the effects of explanatory variables vary with the measure of food security. For instance, TFP growth outweighs trade openness for food availability while the reverse holds for food accessibility.

4.3 Control variables

The estimated coefficients of the three control variables have expected theoretical signs, though food inflation is statistically insignificant. Log of income per capita coefficients, for food availability

Table 5. Standardised coefficients: variables of interest.

		Food availability			Food Access		
Variable	Std.Dev	β	β^*		Std.Dev	β	β^*
lgDESA	0.114			lgUNPREV	0.567		
lgTFPI	0.158	0.109	0.150	lgTFPI	0.130	−0.230	−0.053
lgFDTOP	0.809	0.015	0.108	lgFDTOP	0.834	−0.054	−0.079
NRPFS	0.422	−0.037	−0.136	NRPFS	0.434	0.226	0.173

and access, both significant at 1% level, are 0.133 and −0.687, respectively. The insight is that an increase in income per capita increases food security. In the former, a 1% increase in income raises dietary energy supply by 0.13%, while in the latter, the same magnitude causes a 0.69% fall in undernourishment prevalence. The possibility of food insecurity rises for households with limited income. Evidence of this relationship is overwhelming. Coleman-Jensen et al. (2017) find that high-income households are less likely to be food insecure, while Nord (2009) documents that children with unemployed parents have a higher prevalence of food insecurity than otherwise.

The coefficient for the log of population is negative for food availability and positive for undernourishment. Ideally, higher population growth, ceteris paribus, reduces per capita food availability and restricts accessibility. Given prevailing population growth trends in Africa, the results raise concern on the possibility and the extent to which the continent can end food insecurity. Population Action International (PAI) (2012) reports that most countries with the highest food-insecure people have rapid population growth and high fertility rates. FAO (2017) project that by 2050, the world population will be close to 10 billion. Of concern is that the highest population growth is from Africa and is expected to double by 2050. The United Nations (2020) anticipates that Africa will contribute more than half of the world's population growth between now and 2050. Data from World Population Prospects (WPP) (2019) indicates that the global proportion of Africa's population is projected to increase from 17% in 2020 to 26% in 2050. More recently, Hall et al. (2017) provided evidence that the estimated rapid population growth will be the leading cause of food insecurity in Africa.

Despite the gloomy picture from the population-food security relationship, Africa can explore some opportunities. Early work by Simon (1975) posits that higher population growth increases savings and investment in agricultural services. Pender (1999) highlights that population growth may pressure natural resources. This may, in turn, induce innovations and new production methods beneficial for food production and security. However, Pender (1999) emphasised that such inducements are not natural and automatic. We deduce that some benefits can be reaped from population growth in Africa only if the necessary infrastructure is put in place.

Parameter estimates of food inflation picked positive (negative), though insignificant, signs for undernourishment and (dietary energy supply). This shows that food inflation is detrimental to food security, albeit trivially. The negative impact of food inflation on food security has been confirmed in literature, including Gazdar and Mallah (2013), and Woertz, Soler, and Farrés (2014).

5. Conclusion and recommendations

We used the Panel Corrected Standard Error (PCSE) estimator on panel data from 2005 to 2016 from 13 African countries to infer the impact of agricultural trade liberalisation and agricultural total factor productivity (TFP) growth on food security. The PSCE estimator was chosen for its robustness in the presence of heteroskedasticity, cross-sectional dependence, and serial autocorrelation. For robustness, we use two measures of food security, daily per-capita dietary energy supply, and prevalence of undernourishment. These are proxies for the main pillars of food security, food availability, and access respectively. Unlike existing studies (including Barlow et al. 2020; Bonuedi, Kamasa, and Opoku 2020; Fusco, Colucci, and De Leo 2020) and as a contribution, we included nominal rate of protection given to food security commodities in line with the AoA definition of agricultural trade liberalisation.

The results established that food trade liberalisation and agricultural TFP have significant and favourable food security effects. Our findings are in line with Brooks and Matthews (2015), Clapp (2015), and Mozumdar (2012). However, the impact varies with the measure of food security. Agricultural TFP growth provides higher gains than trade openness for food availability, while the reverse holds for food accessibility. When trade liberalisation is disaggregated into exports and imports, we observe that exports, despite having a lower share of food trade, have higher and more significant effects than imports for food accessibility. Furthermore, domestic agriculture support was found to have a negative effect on food security, confirming its distortionary effects. Accordingly, a one-unit reduction beyond support-free levels increased dietary energy supply by 82.38 kilocalories per day and reduced the prevalence of undernourishment by 4.12%. Lastly, control variables picked expected signs though food inflation is insignificant. Higher population growth and food inflation are associated with deteriorating food security, while increased income per capita improves food security.

We derive policy implications from these findings. To maximise the food security gains, Africa should promote local food production and export incentives and further open agricultural and food trade. This is because exports provide more gains than imports due to agriculture production multiplier effects. There is a need to shift agriculture production growth from output expansion to TFP growth. This calls for increasing productive agriculture expenditure (R&D, innovation, and infrastructure) and reducing distortionary expenditure (producer payments, subsidies). Finally, to neutralise the adverse effects of population growth, more support should be put in agriculture human capital development.

While the study has given important results and conclusions, further examinations can be done to broaden and deepen understanding of the effects of agriculture trade policy on food security. First, only two main components of food security-food availability and accessibility-were under investigation. Future studies can make use of a combined food security index such as the Global Food Security Index (GFSI) (Economist Intelligence Unit 2012), the Ending Rural Hunger Index (ERHI) (Kharas et al. 2015), and the Proteus composite index (Caccavale and Giuffrida 2020). Secondly, we focused on the direct effect of agricultural TFP growth on food security but could not examine its interaction effect with trade openness. Including the trade-TFP growth, index may provide more valuable insights.

Notes

1. For details on measurement and composition of NRP, see Barreiro-Hurle and Witwer (2013).
2. See https://www.ifpri.org/topic/food-security. Accessed 4 September 2020.
3. See FAO (2016b) for a detailed explanation on food self-sufficiency and sovereignty.
4. See Appendix A.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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