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# Enabling trade across borders and food security in Africa

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## Abstract

Widespread food insecurity remains a daunting challenge in Africa, despite significant gains in global efforts to eliminate hunger over the last three decades. This paper examines the effects of easing trade across borders – through reductions in documents, time, and costs to export and import – on food security outcomes in Africa. To control for endogeneity, this paper employs the first-difference instrumental variable estimator based on panel data covering 45 African countries over the period 2006–2015. The results reveal that poor trade facilitation constitutes a significant driver of food insecurity in Africa. In particular, ineffective trade facilitation is associated with significant increments in the prevalence of undernourishment and depth of food deficit, as well as reductions in dietary energy supply adequacy and access to sanitation facilities. The results show that food availability and food access are significantly hampered by higher documentation requirements and lengthier export and import times. The results suggest that reductions in delays from documentary and border compliance promise to be the most effective trade facilitation reforms to enhance food security in Africa.

**Keywords** Food security · Trade facilitation · First-difference instrumental variable · Africa

**JEL classification** O24 · Q18 · F13 · C36

## 1 Introduction

... Africa has the ability to grow and deliver good quality food to put on the dinner tables of the continent's families... However, this potential is not being realized because farmers face more trade barriers in getting their food to market than anywhere else in the world. Too

often, borders get in the way of getting food to homes and communities which are struggling with too little to eat.

Makhtar Diop, the World Bank Vice President for Africa (World Bank 2012).

Achieving a world without hunger remains elusive as hunger pangs continue to afflict about 821 million people today (Food and Agriculture Organization (FAO) et al. 2018). The global burden of undernourishment is most substantial in Asia (515.1 million) and Africa (256.5 million) (FAO et al. 2018), which are also home to several of the world's poorest countries. Despite remarkable declines in global hunger rates since 2000, the levels of hunger in these regions are considered serious or alarming, according to the Global Hunger Index (GHI) (von Grebmer et al. 2018). Disturbingly, undernourishment and severe food insecurity, as reported by the recent issues of *The State of Food Security and Nutrition in the World*, are on the rise again in almost all sub-regions of Africa (FAO et al. 2017, 2018, 2019).

In the face of these alarming signs of increasing food insecurity and malnutrition, the question remains, what can be done to hasten progress towards achieving the Sustainable Development Goals (SDGs) of a world without hunger and

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any form of malnutrition by 2030 (United Nations 2015)? Farmers across the globe already produce enough food to feed about 10 billion mouths (Holt-Giménez et al. 2012) – 1.3 times the global population of 7.6 billion people (Population Reference Bureau 2018). In particular, recent trends show moderate increases in per capita food production and agricultural productivity in most African countries, despite the considerable challenges still facing the sector (Badiane and Collins 2016; Benin 2016). However, chronic hunger and poor nutrition remain unacceptably rife. This paradox of increasing agricultural production coexisting with extreme hunger suggests that merely boosting and diversifying food production (and incomes) is insufficient to effectively address the problems of food insecurity and malnutrition (World Bank 2007).

Climate variability and extremes, conflicts, economic slowdowns, and downturns are some of the drivers of the recent increases in global hunger rates (FAO et al. 2017, 2018, 2019). In addition to these contributory factors, food insecurity in Africa is severely exacerbated by trade-related barriers, which hinder the movement of food from surplus production areas to consumers in neighboring markets in food deficit areas (Mukhtar 2017; World Bank 2012). As Mukhtar (2017) and Brenton and Soprano (2018) observed, ill-developed agricultural supply chains, as well as complex and burdensome import and export procedures, are prevalent in most African countries. These non-tariff trade barriers prevent cost-effective and timely delivery of diverse and nutritious food items from both regional and global markets.

With much of Africa's trade involving time-sensitive, perishable agricultural goods, huge post-harvest food loss constitutes a significant threat to food security on the continent. In Africa and other developing regions, about 40% of food produced is lost or wasted each year between the farm and the fork (Gustavsson et al. 2011; World Economic Forum (WEF) 2014). Food loss occurs partly because of poor trade facilitation and inefficiencies in agricultural supply chains. African farmers face significant trade-related constraints not only in accessing the inputs they need but also in getting their foods to consumers in African cities (World Bank 2012). Enabling trade across borders has, therefore, been identified as instrumental in unlocking Africa's food trade potential, boosting income for farmers, and fostering food security for everyone (World Bank 2012; WEF 2014; Maur and Shepherd 2015; Mukhtar 2017).

Nothing would aid the cause of ending hunger and achieving food security by 2030 more than empirical evidence that substantiates the hypothesized link between trade facilitation reforms and food security. To the best of our knowledge, there is virtually no empirical study that explicitly examines the contribution of easing trade across borders in mitigating hunger in Africa. Previous studies on the impacts of trade facilitation mainly focused on developmental outcomes such as

trade (Sakyi and Afesorgbor 2019; Wilson et al. 2005; Portugal-Perez and Wilson 2012; Hoekman and Shepherd 2015); economic growth (Sakyi et al. 2017; WEF 2013), poverty and inequality (Viet 2015); and social welfare (Sakyi et al. 2018). Only a handful of studies analyzed the impacts of trade on food security (Dithmer and Abdulai 2017; Mary 2019; Fellmann et al., 2014; Baldos and Hertel 2015). For instance, Fellmann et al. (2014) showed that short-term export restrictions (bans, quotas, taxes), in the face of grain harvest failures, can worsen the situation on global grain markets, with disproportional adverse effects on food security in net grain importing countries. Similarly, Mary (2019) demonstrated that increased food trade openness could increase the prevalence of undernourishment in developing countries. In contrast, Dithmer and Abdulai (2017) showed that trade openness contributes significantly to food security. Last but not least, in their literature review, Baldos and Hertel (2015) showed that international trade plays a significant role in dealing with food security risks from climate change. Not much attention, however, has been devoted to analyzing the effects of trade facilitation on food security, particularly in Africa, where food insecurity is widespread and intricate procedures and other non-tariff barriers often obstruct trade across borders.

This paper bridges this lacuna in the literature by presenting empirical evidence on the effects of trade facilitation on food security in Africa. We utilized a panel dataset from 45 African countries over the period 2006–2015 and the first-difference instrumental variable (FDIV) technique to analyze the potential impacts of reduction in trade-related transaction costs, namely, the number of documents required to export and import, time to export and import as well as the cost to export and import, on food security. Unlike Fellman et al. (2014) and other studies that focused on conventional trade barriers, this paper investigates the beneficial effects that reforms directed at accelerating the clearance and movement of goods across borders could have on food security. Thus, instead of tariffs, quotas, embargoes, and other traditional forms of trade restrictions, this paper focuses on the quality of the trading environment and its implications for reducing hunger in Africa. Furthermore, in contrast to cross-country studies, which mainly focused on food availability (Smith and Haddad 2000; van Weezel 2018), this paper acknowledges that food security is a multidimensional concept. Consequently, we employed both composite and dimension-specific indicators to measure food security outcomes in Africa. Trade facilitation – our primary explanatory variable – is also measured similarly. By so doing, this study addresses two crucial questions. First, which dimensions of food security are most affected by a reduction in non-tariff trade barriers? Second, which aspects of trade facilitation need reforms to accelerate progress towards achieving food security in Africa? The

findings from this inquiry are relevant for the implementation of trade facilitation agreements and other regional trade policies in Africa.

The rest of the paper is structured as follows: theoretical linkages, as well as stylized facts about trade facilitation and food security, are presented in the next section. Section 3 provides the model specification and empirical strategy. Section 4 discusses issues related to data sources and measurement of variables. The empirical results are presented and discussed in Sect. 5. The last section concludes the paper with the main findings and some policy implications.

## 2 Trade facilitation and food security: Conceptual linkages and stylized facts

### 2.1 Conceptual linkages between trade facilitation and food security

Although cross-border trade has become more liberalized through lower tariffs and quotas, overall trade costs remain high, typically in developing countries, where non-tariff factors constitute major impediments to international trade (Arvis et al. 2016). These factors include poor-quality infrastructure, dysfunctional logistics services, and overly bureaucratic trade procedures and their resultant delays and high compliance costs. High transaction costs reduce trade and prevent countries from reaping the full benefits of trade liberalization and integration into global value chains (Möise and Sorescu 2013; United Nations 2016). It is against the backdrop of reducing trade costs and expediting the movement, release, and clearance of goods that the implementation of trade facilitation reforms remains a pressing issue on the World Trade Organization's (WTO) agenda. Trade facilitation, according to the WTO (2015), involves the simplification, modernization, and harmonization of international trade procedures as well as the improvement of the trading environment, quality of infrastructure, transparency, and domestic regulations – to reduce transaction costs and ease trade. The impacts of trade facilitation have been examined in several studies, with resounding evidence that improved trade facilitation significantly reduces trade costs and increases trade flows (Anderson and Van Wincoop 2004; Arvis et al. 2016; Möise and Sorescu 2013; Duval et al. 2018).

Food security, according to the FAO (2003), is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This definition captures the fact that food security is a multidimensional concept, encompassing four pillars, namely, food availability, access to food, utilization, and stability. Availability implies the physical existence of food in adequate quantities to meet consumption needs.

National-level food availability is comprised of domestic food production, domestic food reserves, net food imports, and food aid. At the household level, food could be available from own production, purchased from local markets, or gifts or in-kind food assistance. The access dimension of food security is ensured when people have the ability – unimpaired by any physical, economic, and social barriers – to acquire nutritious foods in adequate amounts to meet their dietary needs. Utilization captures biological absorption of nutrients in foods consumed as well as the food environment, including food preparation, allocation, safety and conservation, care and feeding practices, adequate sanitary facilities, and a healthy physical environment. Lastly, stability is achieved when food availability and people's ability to access and utilize food remain stable and sustained over time.

Trade facilitation is theoretically linked to food security through its effects on trade. A caveat worth mentioning is that the relationship between trade and food security is mediated and highly complicated by country-specific policy decisions and other contextual factors. Thus, more trade – through improved trade facilitation or less restrictive tariff and non-tariff measures – does not automatically contribute to food security and different development outcomes. However, as discussed below, trade strongly influences several underlying determinants of food security and malnutrition. Additionally, existing evidence suggests that better trade facilitation measures can, in some cases, result in poverty reduction and improved welfare outcomes for the poor, especially in Africa (Sakyi et al. 2018; WEF 2013).

According to classical trade theories – notably, the Heckscher–Ohlin model (H–O model) – countries stand to gain from trade if they specialize in the production and exportation of commodities of their comparative advantage and import products of their comparative disadvantage. Such gains include fuller utilization of otherwise idle domestic resources, better access to external markets, the inflow of foreign capital, new technology, new ideas and skilled personnel, greater competition and efficiency, improved productivity and incomes, and better prices. However, these welfare gains are not realized in the presence of poor trade facilitation, which increases trade costs and constrains access to regional markets. Improved trade facilitation reduces trade costs, increases trade flows, and allows importers to benefit from lower prices and exporters to receive higher prices for the traded commodities (WTO 2015; Arvis et al. 2016; Duval et al. 2018). According to several trade theories (including the “iceberg” model (Samuelson 1954), new trade theory (Krugman 1980) and heterogeneous firms theory (Melitz 2003)), trade costs drive a wedge between the relative prices faced by exporting and importing countries. This moves trading partners closer to their initial autarkic prices, discourages specialization, and erodes incentives for trade. The results of high trade costs, among others, are lesser trade volumes, reduced consumption

possibilities, and lowered economic welfare. Several studies have shown that slight reductions in trade costs, such as reducing lengthy export and import times or border procedures, can lead to significantly increased trade, with more benefits accruing to developing countries relative to developed countries (Djankov et al. 2010; Moïse and Sorescu 2013; Portugal-Perez and Wilson 2012; Hoekman and Shepherd 2015; Hillberry and Zhang 2015).

Through its effects on several trade-related (welfare) outcomes, trade facilitation ultimately affects the availability, access, stability, and utilization of diverse, safe, and nutritious food products from international markets (see Mukhtar 2017; Dithmer and Abdulai 2017; FAO 2015). Improving trade facilitation has the potential of increasing food availability by expediting the movement of goods across borders and guaranteeing timely delivery of food from international markets to bridge supply gaps. In terms of access, better trade facilitation contributes to improved food security through reduced transaction costs, lower relative prices of imported foods, and increased real return (income) of the country's abundant factors. Trade facilitation also contributes to food security in its stability dimension by ensuring consistent, efficient, and timely food supplies, and hence helps to avert crisis following shortfalls in domestic food production. Enabling trade also leads to an increased variety of food products as well as the nutrition mix available in local markets, thereby enhancing the utilization dimension of food security. Better trade facilitation also improves the health environment within which food is produced, prepared, and consumed by increasing access to improved healthcare technologies, hygiene, and sanitation facilities from international markets. There is evidence that access to sanitation facilities is closely linked to health status and biological absorption of micronutrients in foods consumed (Smith and Haddad 2000).

## 2.2 Stylized facts on food security and trade facilitation in Africa

Achieving food security and eradicating malnutrition in all its forms are top priorities of the 2030 Agenda for Sustainable Development and United Nations Decade of Action on Nutrition 2016–2025. Globally, the number of undernourished persons rose from 777 million in 2015 to about 821 million in 2018. This reversal threatens to erode the gains made in reducing the hungry population from 900 million in 2000. (FAO et al. 2018). Despite a generally global improvement, the food security situation in Africa remains precarious (FAO et al. 2014, 2015, 2017). Table 1 presents the trend in the prevalence of undernourishment in the world by region, with a particular focus on Africa, between 2000 and 2015.

In all the regions of the world, Africa records the highest proportion of people undernourished. In 2015, Africa recorded a prevalence rate of 18.5%. Although it is an improvement

from the 2000 (24.3%) and 2005 (20.8%) figures, Africa performed woefully relative to other regions of the world such as Asia (11.6%), Latin America and the Caribbean (6.6%), Oceania (6.8%), and even the world average (10.6%). Within Africa, undernourishment is most severe in Eastern and Middle Africa, primarily because of conflict and climate extremes. In contrast, the burden of undernutrition is relatively low in Southern and Northern Africa.

Figure 1 also illustrates the regional trends in trading across borders indicators between 2006 and 2015. While almost every region registered improvements in trade facilitation over the period, sub-Saharan Africa and South Asia remain the worst performers concerning the ease of trading across borders. Albeit slow, these declines in the required number of documents, days, and costs to export and import in sub-Saharan Africa, have been achieved on the back of several years of reforms to enable trade across borders.

## 3 Model specification and estimation strategy

### 3.1 Model specification

To quantify the food security effects of trade facilitation, we model food security ( $FS_{it}$ ) in country  $i$  in year  $t$  as a function of trade facilitation ( $TF_{it}$ ), and a vector of theorized correlates of food security ( $C_{it}$ ). The estimable model is specified as:

$$FS_{i,t} = \alpha + \beta TF_{i,t} + \varphi C_{i,t} + \delta_i + \mu_t + \epsilon_{it} \quad (1)$$

where  $\delta_i$  captures country-specific fixed effects (such as unobserved institutional, socio-cultural and geographic attributes that are time-invariant),  $\mu_t$  represents time fixed-effects (such as movements in global market prices, shocks, and technological changes that affect all countries alike).  $\epsilon_{it}$  is the error term. The effect of trade facilitation on food security is measured by  $\beta$ , the parameter of interest. Details of the food security and trade facilitation indicators employed are provided in Sect. 4.

### 3.2 Estimation strategy

The presence of possible endogeneity from a two-way relationship between food security and trade facilitation raises concerns about estimating  $\beta$  consistently. To deal with this concern, we employ the first-difference instrumental variable (FDIV) estimation technique, which proceeds in two steps (Levitt 1996; Wooldridge 2010). In the first step, a first-difference (FD) transformation is done to eliminate the unobserved heterogeneity and mitigate its associated endogeneity biases. The resulting first-difference model is given as:

$$\Delta FS_{i,t} = \beta \Delta TF_{i,t} + \varphi \Delta C_{i,t} + \Delta \epsilon_{it} \quad (2)$$

**Table 1** Prevalence of undernourishment (%) in the world by region, 2000–2015

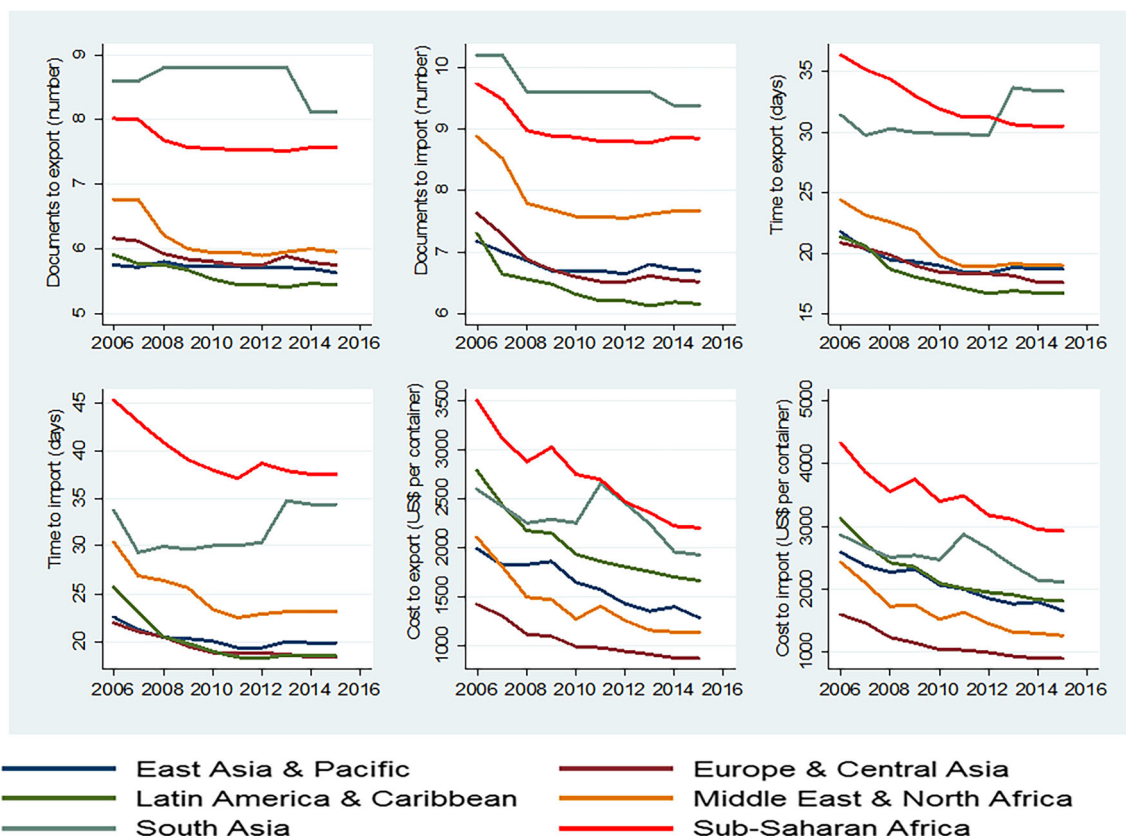
Region/year	2000	2005	2010	2011	2012	2013	2014	2015
Africa	24.30	20.80	18.30	17.90	17.80	17.80	18.10	18.50
Asia	16.70	17.00	13.20	12.80	12.50	12.20	11.90	11.60
Latin America & Caribbean	12.00	9.10	9.1	6.60	6.40	6.30	6.30	6.30
Oceania	5.30	5.30	5.00	5.20	5.30	5.70	6.00	6.40
North America and Europe	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
World	14.70	14.20	11.50	11.20	11.00	10.80	10.70	10.60
African sub-regions								
Northern Africa	6.8	6.3	5.1	4.8	8.5	8.4	8.3	8.3
Eastern Africa	39.30	34.30	30.90	30.20	30.60	30.60	30.90	30
Middle Africa	37.40	29.40	23.80	23.10	22.50	22.30	24.00	24.40
Southern Africa	7.10	6.40	6.70	6.30	6.20	6.20	6.50	6.60
Western Africa	15.10	12.00	10.00	9.90	9.90	9.80	9.80	10.40

Source: FAO, IFAD, UNICEF, WFP, and WHO (2017)

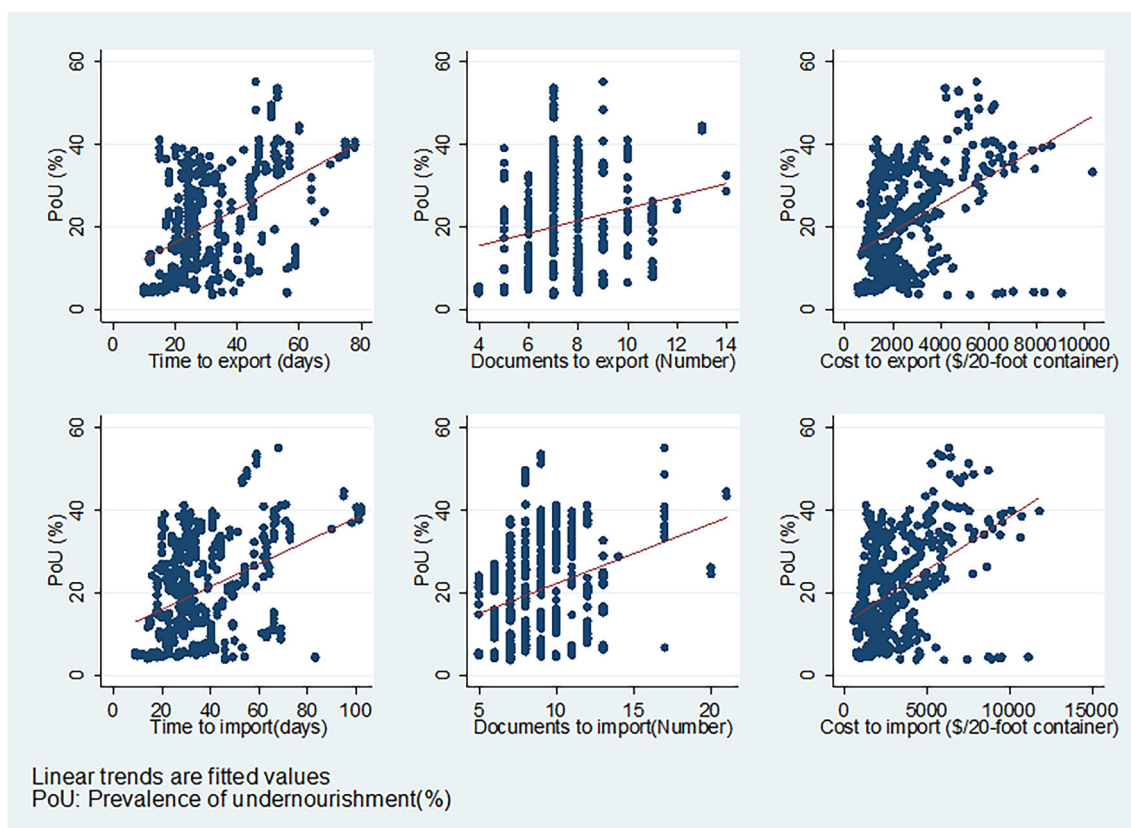
Additionally, it must be acknowledged that our sample consists of several self-governing African countries that differ in their policy decisions, institutions, culture, geography, and level of development. While these country-specific, contextual factors may influence the linkage between trade facilitation on food security, most of them are time-invariant or slow-changing. Consequently, the use of FD transformation helps

to remove many of these unchanging factors that vary across countries.

However, an ordinary least squares (OLS) estimation of the FD Eq. (2) may still yield a biased estimate of  $\beta$ , due to potential correlation between  $\Delta TF_{i,t}$  and  $\Delta \epsilon_{it}$ . This concern is addressed in the second step of the FDIV approach, which involves a two-stage least-squares (2SLS) estimation to obtain



**Fig. 1** Regional trends in trade facilitation indicators between 2006 and 2015. (Source: Authors’ construct based on World Bank Doing Business Indicators)



**Fig. 2** Scatterplot of the prevalence of undernourishment (PoU) against trade facilitation indicators in Africa

a consistent estimate of  $\beta$ . The first-stage regression of the FDIV estimator can be specified in the reduced form as:

$$\Delta TF_{i,t} = \gamma \Delta Z_{i,t} + \varphi \Delta C_{i,t} + \Delta \epsilon_{it} \quad (3)$$

where  $Z_{i,t}$  are valid instrumental variables, which are (exogenous) uncorrelated with  $\Delta \epsilon_{it}$  but strongly associated with trade facilitation. Finding truly exogenous instruments is difficult. However, we propose the distance to the frontier (DTF) score of trading across borders as an instrument for our trade facilitation indicators.<sup>1</sup> The DTF score measures how far away, on average, an economy is from the best practice (i.e., the frontier), set by the best-performing economy for each indicator at a given time. An economy's DTF score is scaled from 0 (the worst performance) to 100 (the frontier) (World Bank 2016). By intuition, we consider the DTF score to be a credible instrument for three reasons. Firstly, with the frontier being non-static, an economy's distance to the frontier

<sup>1</sup> By excluding all domestic time costs, Djankov et al. (2010) use export time from the border of a landlocked country onto the ship in neighboring country(ies) as an instrument for time of exporting. We do not adopt this instrument because it is only applicable to a restricted sample of landlocked countries. However, our proposed instrument – the DTF score – also excludes all domestic time and transaction costs associated with trading across borders because it measures each economy's distance from the frontier across all economies and across time.

depends mostly on global (exogenous) variations in best regulatory practices. Secondly, domestic trade reforms may improve trade facilitation, and consequently close the gap to the frontier in a given time. However, we have no reason to believe that, except through trade facilitation, such improvements in the DTF score can directly influence food security outcomes in the country. Thirdly, while it may reflect absolute changes in the regulatory environment over time (World Bank 2018), it is of no direct target for trade policy.

## 4 Data and measurement issues

The data used in this paper covered 45 African countries over the period 2006–2015. The availability of data dictates the selection of countries and the study period. A concise description of the variables and countries included in the study are provided in Tables 8 and 9 respectively (in the appendix).

### 4.1 Food security indicators

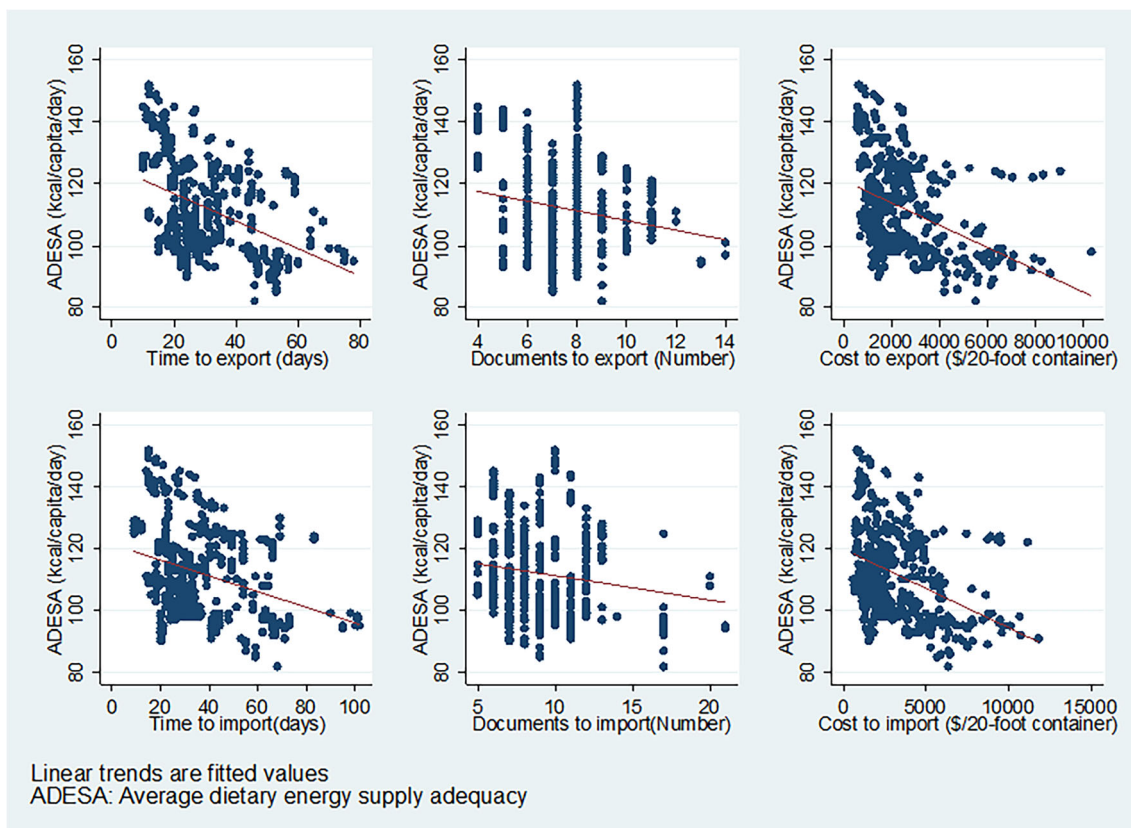
Food security is a multidimensional concept, and literature is replete with indicators at the individual, household, and macro levels (Pangaribowo et al. 2013). A good indicator of food security is one that encompasses all four

pillars: (1) availability, (2) access (3) stability, and (4) utilization. Previous cross-country studies mainly focused on national food availability, proxied by dietary energy supply/consumption (Smith and Haddad 2000, 2001; van Weezel 2018). In this paper, we employ both composite and dimension-specific indicators of food security. We capture the overall level of food security by the prevalence of undernourishment. The reason is that, the United Nations has adopted it as one of the official indicators to track progress towards SDG Target 2.1, which aims to end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round by 2030. Drawing from the FAO (2017) Suite of Food Security Indicators, we also used (1) average dietary energy supply adequacy to proxy food availability, (2) depth of food deficit to capture food access, and (3) access to improved sanitation facilities to measure food utilization. Worthy of note is that we do not analyze the effects of trade facilitation measures on the stability of pillar of food security. This is because stability cuts across the availability, access and utilization dimensions of food security, and is indirectly accounted for in our estimated models through political stability, inflation, as well as rainfall and temperature shocks.

### 4.2 Trade facilitation indicators

Similar to food security, trade facilitation is also multifaceted. In this paper, we rely on six indicators of the ease of trading across borders from the World Bank Doing Business project: (1) documents to export (2) documents to import (3) time to export (4) time to import (5) cost to export (6) cost to import. These indicators measure the documentary procedures, time, and cost associated with the logistical process of exporting and importing goods (ESCAP et al. 2015). Higher values of these indicators signal higher levels of what we call “trade disfacilitation” – simply, inefficient trade facilitation. We also construct an overall measure for trade disfacilitation based on these six indicators through principal component analysis (PCA). Based on the Kaiser criterion of eigenvalue greater than one, only the first principal component is retained as the composite index. The PCA results are reported in Table 10. Through min-max transformation, the trade disfacilitation index ranges from 0 to 1, with higher values implying less efficient trade facilitation, mirrored in onerous documentary procedures, lengthy time to export and import, and higher costs to export and import.

As depicted in Figs. 2 and 3, trade disfacilitation is associated with a higher prevalence of undernourishment and lower average dietary energy adequacy (food availability) in Africa.



**Fig. 3** Scatterplot of average dietary energy supply adequacy (ADESA) against trade facilitation indicators in Africa. (Source: Authors’ constructs based on FAO Food Security Indicators and World Bank Doing Business)



This paper is, therefore, premised on the hypothesis that, all else being equal, poor trade facilitation threatens food security in Africa.

### 4.3 Control variables

Gleaning from existing literature (Smith and Haddad 2001; Dithmer and Abdulai 2017; van Weezel 2018), we consider several determinants of food security. These covariates relate to economic, agricultural, demographic, political, and climatic factors that may confound the food security effects of trade facilitation reforms. The quality of the macroeconomic environment is captured by the inflation rate. Trade openness, as an indicator of trade liberalization and integration into the global economy, has been shown to markedly contribute to food security by improving dietary energy consumption and dietary diversity (Dithmer and Abdulai 2017).

The level of economic development is captured by real GDP per capita. *Ceteris paribus*, more developed economies have higher income per capita, which gives them better access to food and makes them more food secure than less developed ones. Agricultural productivity is proxied by cereal yield, improvement of which is expected to bestow beneficial effects on household food security. Demographic controls include population growth rate and percentage of the rural population. The food security effects of the population variables are indeterminate as rapid population growth, particularly in rural areas, may either yield positive productivity effects or worsen food security by increasing pressure on limited resources. Political shocks are captured by political stability and absence of violence or terrorism. Also, climatic shocks are measured by annualized anomalies of monthly temperature and rainfall realizations from their corresponding long-term averages divided by their respective long-term standard deviations. Both political instability and climatic shocks are expected to affect food security adversely. Table 2 reports the summary statistics of the variables employed.

## 5 Results and discussion

This section presents and discusses the empirical results from the food security–trade facilitation regression models. The first-stage results from pooled OLS estimation of Eq. (3) are reported in Table 3. In a nutshell, these results show that the proposed instrument (distance to the frontier) is negatively and significantly associated with all the trade facilitation indicators. Expectedly, the results suggest that the closer a country is to the frontier (higher DTF score), the better trade is enabled across its borders. The second-stage results showing the effects of trade disfacilitation on alternative indicators of food security are reported in Tables 4, 5, 6, and 7. Reported in each table are seven regression models. The impact of the

composite trade disfacilitation index on food security is reported under Column 1 in each table. Columns 2–7 correspond to the food security effects of each trade facilitation indicator – documents to export, documents to import, time to export, time to import, cost to export, and cost to import.

Before delving into the core results, we momentarily consider the diagnostic statistics reported at the bottom of each table. The null hypothesis that each trade facilitation variable can be treated as exogenous is rejected across almost all the specifications. This result undeniably confirms our suspicion of trade facilitation being endogenous, hence the use of an instrumental variable estimator. The validity of our proposed instrument – the distance to the frontier score for trading across borders – is assessed via the Anderson conical correlation Lagrangian Multiplier (LM) test for under-identification and Cragg-Donald Wald  $F$  test for weak identification. In most cases, the  $p$  values of the LM and  $F$  tests are less than a 5% significance level. This leads us to reject the null hypothesis of under-identification and weak identification of the regression models. This implies that the DTF score (i.e., the instrument) is not only correlated with each trade facilitation measure (i.e., endogenous regressors), but this correlation is also strong or statistically significant at the conventional error levels (as shown in Table 3). While the exclusion restriction is not directly testable, its satisfaction is justified previously (see Sect. 3).

Turning to the main results, the coefficients of the composite trade disfacilitation index are both consistent with theoretical expectations and statistically significant at 5% level. Poorer trade facilitation (higher composite index) is found to significantly exacerbate Africa's overall food insecurity (higher prevalence of undernourishment in Table 4). This result is buttressed by the ensuing reduction in food availability (lower dietary energy supply adequacy in Table 5), a decline in accessibility (greater depth of food deficit in Table 6), and imperiled utilization (reduced access to improved sanitation facilities in Table 7). The results reveal that all other things held constant, a 1% increase in the trade disfacilitation index is significantly associated with 1.6% increase in the prevalence of undernourishment, 0.36% decline in the adequacy of dietary energy supply, 1.8% increase in the depth of food deficit and 0.26% decline in population with access with improved sanitation facilities. While the effects may not be direct, these results suggest that poor trade facilitation can exert harmful effects on food security in Africa. However, differential effects exist among the four pillars of food security. Access is the worst affected dimension, followed by availability and utilization in descending order. These results are primarily supported by the claims of Mukhtar (2017).

As aforesaid, trade facilitation is a multilayered concept. It is, therefore, essential for policymakers to know which aspects of the logistical process of international trade need to be reformed to leverage the beneficial effects of trade facilitation

**Table 2** Summary statistics

Variable	Obs., <i>N</i>	Mean	St Dev.	Min	Max
Food security indicators					
Prevalence of undernourishment (%)	440	20.715	12.336	3.600	55.100
Average dietary energy supply adequacy	450	111.962	14.671	82	152
Depth of the food deficit	440	149.711	98.017	24	453
Access to sanitation facilities (%)	450	37.282	23.812	8.200	94.700
Trade facilitation indicators					
Documents to export (number)	450	7.489	1.720	4	14
Documents to import (number)	450	9.016	2.751	5	21
Time to export (days)	450	31.049	14.471	10	78
Time to import (days)	450	37.100	18.545	9	102
Cost to export (US\$)	450	2501.809	1680.443	547	10,303
Cost to import (US\$)	450	3110.660	2165.435	577	11,776
Composite trade disfacilitation index	450	0.352	0.208	0	1
Controls					
Trade (% of GDP)	427	78.648	31.378	21.333	311.355
Political stability	450	-0.436	0.769	-2.690	1.180
Cereal yield (kg/ha)	450	1602.323	1262.565	34.300	9453.700
GDP per capita	450	4274.075	4292.819	597.700	18,864.100
Inflation, (%)	448	63.388	1154.059	-35.837	24,411.030
Population growth (%)	450	2.409	0.803	0.132	4.183
Rural population (%)	450	57.695	16.891	12.844	86.687
Rainfall shock	450	0.025	0.140	-0.430	0.525
Temperature shock	450	0.076	0.163	-0.380	1.052
Instrument					
Distance to the frontier score	450	49.418	20.266	1.870	87.740

Source: Authors' calculation from FAO Food Security Indicators, World Bank Doing Business, World Development Indicators, and Climate Change Knowledge Portal

and expedite progress towards eradicating hunger and poverty. To identify which dimensions of trade facilitation reforms are most promising in Africa's fight against hunger, we now analyze the results (Models 2–7) from employing the six primary indicators. The results show that a higher number of documents required to export is associated with poorer food security outcomes, holding all other factors constant. However, this association is only statistically significant for the availability and utilization pillars of food security in Tables 5 and 7 respectively. Similarly, one more documentary requirement for imports is found to increase the prevalence of undernourishment by 0.07%, reduce dietary energy supply adequacy by 0.02%, increase the food deficit gap by 0.08% and diminish access to sanitation facilities by 0.01%. These coefficients (in Tables 4, 5, 6, and 7) are statistically significant at the conservative error levels. These results demonstrate the adverse effects excessive documentation could have on food security outcomes in Africa.

With lackluster agricultural output growth vis-à-vis population growth, most African countries tend to rely on food imports to bridge domestic food supply gaps. To the extent

that Africa has been a net food importer since the mid-1970s (Rakotoarisoa et al. 2012), and annual food import bills projected to soar sharply from \$35 billion to \$110 billion by 2025 (African Development Bank 2016), imports are central to Africa's food security. Improving domestic food productivity remains a useful policy option to win the war against chronic hunger and food insecurity in the long-run. However, food imports will continue to be vital in filling food supply gaps and improving food security in the short-to-medium run. In contrast to 3–6 import documents required in more developed and food secure countries (i.e., 3 documents in North America, 4.5 in the Euro area, and 5.15 in high-income countries (World Bank 2015)), over 8 documents are required per shipment of imported goods in Africa (see Table 2). Such burdensome documentation and customs procedures create unnecessary delays at the border and foist considerable losses on importers due to spoilage of imported consignments (Durkin 2017). Therefore, simplifying and harmonizing import documentation procedures will not only speed up border processing and customs clearance but also the movement of foodstuffs along the food chain from surplus

**Table 3** First-stage regression results

	Trade disfacilitation index	Documents to export	Documents to import	Time to export	Time to import	Cost to export	Cost to import
Distance to the frontier	-0.010*** (0.001)	-0.093*** (0.028)	-0.167*** (0.042)	-0.567*** (0.089)	-0.784*** (0.123)	-35.525** (14.555)	-64.400*** (14.321)
Trade openness	-0.008 (0.007)	0.057 (0.227)	-0.105 (0.385)	-0.917 (0.840)	-2.831* (1.695)	158.724 (212.722)	-59.201 (210.453)
Political stability	-0.002 (0.003)	-0.110 (0.096)	-0.278** (0.130)	0.888* (0.531)	1.158 (0.866)	-49.835 (77.225)	-76.577 (88.104)
Agricultural productivity	-0.003 (0.003)	-0.043 (0.062)	-0.065 (0.116)	-0.073 (0.340)	-1.129* (0.662)	8.156 (53.121)	49.925 (64.922)
Rural population	0.001 (0.119)	-2.141 (2.754)	-7.393 (4.675)	3.656 (14.947)	-6.732 (21.381)	2922.556 (2851.809)	1986.354 (3394.050)
GDP per capita	-0.013 (0.021)	0.449 (0.422)	0.319 (0.646)	2.525 (2.334)	6.483* (3.707)	-845.144 (520.399)	-1116.383 (688.952)
Inflation	0.001 (0.002)	-0.014 (0.087)	0.067 (0.067)	0.144 (0.249)	0.592* (0.318)	-30.914 (53.203)	-25.501 (75.081)
Population growth	-0.009 (0.011)	-0.332* (0.194)	-0.610 (0.371)	0.636 (0.871)	0.519 (1.536)	-57.286 (214.856)	60.466 (233.871)
Rainfall shock	0.007 (0.006)	0.320* (0.191)	0.820** (0.397)	-0.545 (0.602)	0.420 (1.111)	-124.644 (166.472)	-135.496 (114.022)
Temperature shock	-0.008 (0.005)	-0.125 (0.112)	0.032 (0.203)	-0.450 (0.564)	-2.580* (1.410)	106.591 (124.755)	-58.096 (174.019)
Constant	-0.001 (0.002)	0.053 (0.032)	0.067 (0.064)	-0.066 (0.175)	-0.264 (0.246)	-35.944 (36.183)	-14.960 (52.524)
R <sup>2</sup> <sub>adj</sub>	0.775	0.308	0.346	0.437	0.392	0.074	0.170
Observations	380	380	380	380	380	380	380

Robust standard errors in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

to deficit areas. With annual global food losses or a waste of 1.3 billion tons (Gustavsson et al. 2011), cutting documentation-induced delays will be instrumental in minimizing caloric losses from the farm to the plate, closing the food deficit gap and augmenting food availability (World Economic Forum 2014; Mukhtar 2017).

Further, the adverse effects of excessive export and import documentation are substantiated by the estimated impacts of time costs on food security. From Tables 4, 5, 6, and 7, the coefficients of both time to export and import are both theoretically consistent and statistically significant across all specifications. Each extra day an export consignment is delayed, corresponds to a 0.02% increase in undernourished population, 0.004% decline in dietary energy adequacy, 0.022% increase in the food deficit gap, and 0.003% fall in the population with access to proper sanitation facilities. Similarly, as shown in Tables 4, 5, 6, and 7, a day's delay in importing is found to swell the undernourished population by 0.013%, dampen dietary energy supply adequacy by 0.003%, widen the depth of food deficit by 0.014% and shrink the proportion

of the population with access to sanitation facilities by 0.002%. With the bulk of Africa's trade involving time-sensitive agricultural commodities, the importance of achieving efficiency in intra-and inter-continental trade and reducing the time taken to export and import cannot be overstressed.

In addition to cumbersome documentation and customs formalities, numerous checkpoints and roadblocks hamper intra-African trade (Mercier 2018; Barka 2012). These translate into lengthy waiting times and erratic delivery times for traders. Per our sample, it takes on average 31.05 days to export and 37.1 days to import in Africa (see Table 2). These trading durations are 5–9 times longer than what it takes for countries at the frontier to export (6 days) and import (4 days) in 2015 (World Bank 2014). Overall, such hold-ups inhibit the timely availability of dispatched goods, including food products, from external markets and aggravate food insecurity situations. Gustavsson et al. (2011) reported that 40% of food losses occur at retail and consumer stages in developed countries. However, in developing countries, over 40% of the food losses is owed to several factors, including

**Table 4** FDIV estimation of the effects of trade facilitation on the prevalence of undernourishment

	Dependent variable: prevalence of undernourishment						
	1	2	3	4	5	6	7
Trade openness	0.051 (0.038)	-0.001 (0.064)	0.027 (0.040)	0.052 (0.033)	0.069* (0.039)	0.004 (0.058)	-0.068 (0.076)
Political stability	-0.033 (0.021)	-0.017 (0.025)	-0.006 (0.012)	-0.034 (0.025)	-0.033 (0.020)	0.046 (0.043)	0.054 (0.043)
Agricultural productivity	0.006 (0.009)	0.005 (0.010)	0.002 (0.006)	-0.003 (0.009)	0.011 (0.012)	-0.011 (0.018)	-0.012 (0.018)
Rural population	-0.014 (0.190)	0.105 (0.238)	0.088 (0.208)	-0.133 (0.195)	-0.046 (0.190)	0.086 (0.252)	0.093 (0.259)
GDP per capita	-0.055 (0.111)	-0.130 (0.103)	-0.149** (0.064)	-0.169** (0.071)	-0.252*** (0.054)	-0.611* (0.369)	-0.633* (0.333)
Inflation	-0.024* (0.014)	-0.011 (0.025)	-0.025 (0.016)	-0.023 (0.015)	-0.029** (0.014)	-0.036 (0.022)	-0.029 (0.025)
Population growth	0.093 (0.065)	0.127* (0.073)	0.110* (0.057)	0.062 (0.058)	0.045 (0.041)	0.049 (0.055)	0.096* (0.052)
Rainfall shock	-0.028 (0.024)	-0.078** (0.036)	-0.078** (0.032)	-0.004 (0.018)	-0.022 (0.020)	-0.047 (0.041)	-0.083 (0.073)
Temperature shock	0.016 (0.016)	0.030 (0.022)	0.007 (0.019)	0.015 (0.017)	0.044** (0.020)	0.055* (0.031)	0.044 (0.033)
Trade disfacilitation index	1.576** (0.776)						
Documents to export		0.165 (0.108)					
Documents to import			0.067* (0.039)				
Time to export				0.019** (0.009)			
Time to import					0.013** (0.006)		
Cost to export						-0.767 (0.711)	
Cost to import							-0.857 (0.643)
Constant	-0.004 (0.091)	0.037 (0.114)	0.027 (0.098)	-0.065 (0.090)	-0.024 (0.089)	-0.012 (0.105)	-0.012 (0.108)
No. of observations	371	371	371	371	371	371	371
No. of countries	43	43	43	43	43	43	43
Endogeneity test $\chi^2$	16.534***	18.497***	17.841***	16.507***	17.458***	19.470***	19.653***
Anderson LM stat	8.888***	3.33**	6.92***	9.77***	9.83***	0.00	0.08
Cragg-Donald Wald F	8.857***	3.26*	6.86***	9.76***	9.82***	0.00	0.07

Robust standard errors in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

border delays, poor trade-related infrastructure, and inadequate post-harvest processing and storage facilities at the early and middle stages of the food supply chain. Djankov et al. (2010) found that time delays reduce trade, with a relatively larger impact on exports of time-sensitive goods,

precisely perishable agricultural products. A decline in trade, in turn, may imperil food security.

While the coefficients of most control variables are not robustly statistically significant, the direction of their effects deserves some discussions. By focusing on the models for

**Table 5** FDIV estimation of the effects of trade facilitation on average dietary energy supply adequacy

	Dependent variable: average dietary energy supply adequacy						
	1	2	3	4	5	6	7
Trade openness	-0.018*	-0.006	-0.012	-0.018**	-0.022**	-0.007	0.009
	(0.010)	(0.016)	(0.010)	(0.009)	(0.009)	(0.013)	(0.018)
Political stability	0.006	0.002	-0.001	0.006	0.006	-0.012	-0.014
	(0.005)	(0.006)	(0.003)	(0.006)	(0.005)	(0.010)	(0.010)
Agricultural productivity	-0.002	-0.002	-0.001	-0.000	-0.003	0.002	0.002
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)
Rural population	0.025	-0.002	0.003	0.052	0.033	0.001	-0.001
	(0.041)	(0.051)	(0.043)	(0.045)	(0.039)	(0.055)	(0.058)
GDP per capita	0.024	0.041*	0.046***	0.050**	0.069***	0.152*	0.157**
	(0.024)	(0.024)	(0.016)	(0.020)	(0.015)	(0.087)	(0.077)
Inflation	0.006	0.003	0.006	0.006	0.007*	0.009	0.007
	(0.004)	(0.007)	(0.005)	(0.005)	(0.004)	(0.006)	(0.006)
Population growth	-0.029	-0.036	-0.033*	-0.022	-0.018	-0.019	-0.030**
	(0.022)	(0.023)	(0.019)	(0.020)	(0.013)	(0.013)	(0.014)
Rainfall shock	0.004	0.015**	0.015**	-0.001	0.003	0.009	0.017
	(0.006)	(0.007)	(0.007)	(0.004)	(0.005)	(0.009)	(0.017)
Temperature shock	-0.002	-0.005	0.000	-0.002	-0.009	-0.011	-0.008
	(0.004)	(0.006)	(0.006)	(0.005)	(0.005)	(0.007)	(0.008)
Trade disfacilitation index	-0.363**						
	(0.173)						
Documents to export		-0.038*					
		(0.022)					
Documents to import			-0.015*				
			(0.009)				
Time to export				-0.004*			
				(0.002)			
Time to import					-0.003**		
					(0.001)		
Cost to export						0.176	
						(0.172)	
Cost to import							0.197
							(0.155)
Constant	0.009	0.000	0.003	0.023	0.014	0.011	0.011
	(0.019)	(0.024)	(0.020)	(0.020)	(0.018)	(0.022)	(0.024)
No. of observations	380	380	380	380	380	380	380
No. of countries	44	44	44	44	44	44	44
Endogeneity test $\chi^2$	12.798***	13.874***	13.501***	13.453***	12.731***	14.315***	14.476***
Anderson LM stat	9.02***	3.35*	6.99***	9.95***	9.95***	0.00	0.08
Cragg-Donald Wald F	8.993***	3.28*	6.92***	9.95***	9.95***	0.00	0.07

Robust standard errors in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

which trade facilitation variables are significant, we identify some consistent patterns in the estimated results. Contrary to our hypothesized expectations, our results suggest that trade openness is inversely associated with food security outcomes, albeit insignificant. While this result contradicts the findings

of Dithmer and Abdulai (2017), it is consistent with Mary (2019), who showed that higher food trade openness leads to increased hunger in developing countries. This result, to some extent, substantiates our argument that merely opening borders to international trade may not necessarily lead to

**Table 6** FDIV estimation of the effects of trade facilitation on the depth of food deficit

	Dependent variable: depth of food deficit.						
	1	2	3	4	5	6	7
Trade openness	0.058 (0.042)	-0.002 (0.073)	0.030 (0.045)	0.058 (0.038)	0.077* (0.043)	0.004 (0.065)	-0.077 (0.084)
Political stability	-0.038* (0.023)	-0.019 (0.028)	-0.006 (0.013)	-0.038 (0.028)	-0.037* (0.022)	0.052 (0.049)	0.061 (0.049)
Agricultural productivity	0.006 (0.010)	0.004 (0.012)	0.002 (0.008)	-0.004 (0.011)	0.012 (0.014)	-0.014 (0.021)	-0.014 (0.021)
Rural population	-0.024 (0.209)	0.111 (0.264)	0.091 (0.228)	-0.160 (0.214)	-0.061 (0.206)	0.089 (0.278)	0.098 (0.287)
GDP per capita	-0.063 (0.126)	-0.148 (0.119)	-0.170** (0.075)	-0.193** (0.081)	-0.287*** (0.062)	-0.694* (0.419)	-0.719* (0.375)
Inflation	-0.028* (0.015)	-0.013 (0.028)	-0.029 (0.018)	-0.027 (0.017)	-0.034** (0.016)	-0.041* (0.025)	-0.033 (0.028)
Population growth	0.112 (0.074)	0.150* (0.082)	0.132** (0.064)	0.077 (0.066)	0.058 (0.045)	0.062 (0.062)	0.116** (0.059)
Rainfall shock	-0.030 (0.028)	-0.087** (0.040)	-0.087** (0.036)	-0.003 (0.021)	-0.023 (0.024)	-0.052 (0.046)	-0.093 (0.082)
Temperature shock	0.019 (0.017)	0.036 (0.025)	0.010 (0.022)	0.019 (0.020)	0.051** (0.023)	0.064* (0.035)	0.052 (0.038)
Trade disfacilitation index	1.788** (0.849)						
Documents to export		0.188 (0.118)					
Documents to import			0.076* (0.043)				
Time to export				0.022** (0.011)			
Time to import					0.014** (0.007)		
Cost to export						-0.870 (0.811)	
Cost to import							-0.972 (0.729)
Constant	-0.005 (0.100)	0.041 (0.126)	0.030 (0.108)	-0.074 (0.099)	-0.028 (0.097)	-0.015 (0.116)	-0.015 (0.119)
No. of observations	371	371	371	371	371	371	371
No. of countries	43	43	43	43	43	43	43
Endogeneity test $\chi^2$	17.306***	19.233***	18.647***	17.538***	18.427***	20.38***	20.597***
Anderson LM stat	8.89***	3.33*	6.92***	9.77***	9.83***	0.00	0.08
Cragg-Donald Wald F	8.86***	3.26*	6.86***	9.76***	9.82***	0.00	0.07

Robust standard errors in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

improved food security, unless trade is effectively facilitated. One reason is that most of the world’s poor and undernourished people dwell in rural areas, where weak transport infrastructure and other market imperfections impede the movement of (imported or locally produced) food from surplus

areas (Mary 2019). It is also likely that an increased supply of low-cost, imported foods may suppress local food prices as well as the incomes of producers and rural households, who heavily depend on cash from marketed surplus to access healthy foods through the market (Sibhatu and Qaim 2017).

**Table 7** FDIV estimation of the effects of trade facilitation on access to basic sanitation facilities

	Dependent variable: access to sanitation facilities						
	1	2	3	4	5	6	7
Trade openness	-0.004 (0.006)	0.005 (0.008)	0.000 (0.006)	-0.004 (0.006)	-0.007 (0.006)	0.004 (0.009)	0.016 (0.013)
Political stability	0.003 (0.004)	0.000 (0.005)	-0.001 (0.003)	0.003 (0.004)	0.003 (0.004)	-0.010 (0.006)	-0.011 (0.007)
Agricultural productivity	-0.005** (0.002)	-0.005 (0.004)	-0.004 (0.003)	-0.004 (0.002)	-0.006** (0.002)	-0.002 (0.004)	-0.002 (0.004)
Rural population	-0.003 (0.020)	-0.022 (0.034)	-0.020 (0.025)	0.016 (0.020)	0.002 (0.018)	-0.021 (0.036)	-0.022 (0.038)
GDP per capita	-0.007 (0.019)	0.006 (0.025)	0.009 (0.018)	0.012 (0.016)	0.026* (0.014)	0.085* (0.046)	0.089* (0.050)
Inflation	0.001 (0.004)	-0.001 (0.006)	0.001 (0.004)	0.001 (0.004)	0.002 (0.004)	0.003 (0.006)	0.002 (0.006)
Population growth	-0.003 (0.007)	-0.009 (0.012)	-0.006 (0.009)	0.002 (0.007)	0.005 (0.007)	0.004 (0.011)	-0.004 (0.013)
Rainfall shock	0.003 (0.003)	0.011 (0.007)	0.011** (0.006)	0.000 (0.003)	0.003 (0.003)	0.007 (0.006)	0.013 (0.009)
Temperature shock	-0.001 (0.003)	-0.003 (0.005)	0.001 (0.004)	-0.001 (0.003)	-0.005 (0.003)	-0.007 (0.007)	-0.005 (0.006)
Trade disfacilitation index	-0.262** (0.102)						
Documents to export		-0.028* (0.016)					
Documents to import			-0.011** (0.005)				
Time to export				-0.003** (0.001)			
Time to import					-0.002*** (0.001)		
Cost to export						0.127 (0.081)	
Cost to import							0.142 (0.094)
Constant	0.009 (0.009)	0.002 (0.016)	0.004 (0.012)	0.018** (0.009)	0.012 (0.009)	0.010 (0.015)	0.010 (0.016)
No. of observations	380	380	380	380	380	380	380
No. of countries	44	44	44	44	44	44	44
Endogeneity test $\chi^2$	23.043***	23.558***	24.259***	25.093***	23.096***	23.716***	23.776***
Anderson LM stat	9.02**	3.35*	6.99**	9.95**	9.95**	0.00	0.08
Cragg-Donald Wald F	8.99**	3.28*	6.92**	9.95**	9.95**	0.00	0.07

Robust standard errors in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Further, improved political stability is associated with a reduction in the prevalence of undernourishment, increment in dietary energy supply adequacy, and decline in depth of food deficit. Though not robustly significant, this outcome is consistent with existing evidence that adverse political shocks,

conflicts, and terrorism are injurious to food security, possibly due to significantly constrained production and access to markets during political upheavals (Dithmer and Abdulai 2017; van Weezel 2018). The results also show that agricultural growth may not necessarily translate into better food security

outcomes. This may be because even though the relationship between agricultural production and food intake is intuitively direct, it is mediated by several individual, (intra)household, and community-level factors that may enhance or negate the effects of agricultural growth on nutritional status. This finding is consistent with the well-established consensus that (non)agricultural growth alone is insufficient to reduce malnutrition unless it is coupled with strategic investments in complementary areas, such as education, health, women empowerment, and infrastructure (World Bank 2007; Ecker et al. 2012).

The coefficients of GDP per capita are rightly signed, suggesting higher incomes may facilitate access to diverse goods and services, which are beneficial to food security and overall wellbeing. Inflationary pressures are associated with improved food security outcomes: lower prevalence of undernourishment, higher dietary energy supply adequacy, and lower depth of food deficit. This finding is consistent with Sakyi et al. (2018), who found that inflationary tendencies can be welfare-enhancing in Africa. These beneficial effects may be true for net selling households, whose supply of commodities may rise with upward price movements, especially when markets are given sufficient time to adjust. For net sellers, this may lead to higher farm revenue, higher purchasing power, and better access to (non-self-produced) diverse, healthy foods in the market.

Lastly, a higher rate of population growth is associated with reduced food security, as increasing population means a higher demand for food. This may result in added pressure on scarce resources and food shortages. These undesirable effects of accelerating population growth rate are seen in higher prevalence in undernourishment, lower dietary energy supply adequacy, wider food-deficit gaps, and lower access to sanitation facilities. The effects of the climate variables are mixed, with rainfall (temperature) shocks being associated with better (worse) food security outcomes.

## 6 Conclusions

In recent years, the prevalence of undernourishment has been on the rise in the developing world, particularly in Africa. This has not only resulted in reversals of trends in global hunger after decades of steady decline but also derailment of progress towards achieving the Sustainable Development Goals of ending all forms of hunger and malnutrition by 2030. Trade-related barriers, besides climate variability, weather extremes, and conflict, constitute a major driver of food insecurity in Africa. However, little research attention has been devoted to analyzing the effects of reductions in non-tariff barriers and the associated transaction costs on food security. This paper fills this knowledge gap by examining the effects of trade facilitation measures on food security in Africa. In

particular, we focus on the role of reductions in non-tariff trade barriers such as bureaucratic at-the-border documentary requirements, lengthy export and import times, and high real trade costs in improving food security outcomes in Africa.

Our sample covered 45 African countries over the period 2006–2015. The first-difference instrumental variable estimator was used to address concerns related to unobserved heterogeneity and potential endogeneity. The results demonstrate that poor trade facilitation can significantly exacerbate food insecurity in Africa. Specifically, we find evidence that non-tariff barriers can significantly increase the prevalence of undernourishment in Africa by reducing dietary energy supply adequacy, expanding the depth of food deficit, and restricting access to sanitation facilities. Access is found to be the worst affected dimension of food security, followed by availability and utilization. We also found high documentary requirements and lengthy export and import times to be significant drivers of the negative effect of low trade facilitation on food security in Africa.

From a policy standpoint, these findings have implications for the pursuit of trade facilitation initiatives in Africa, including the implementation of the recent WTO Trade Facilitation Agreement. The main results imply that policies to reduce undue delays in cross-border trade and ensure timely delivery of goods from external markets promise to be the most significant trade facilitation measures to enhance food security in Africa. Firstly, delay-induced logistics costs can be reduced by streamlining, harmonizing, and modernizing trade procedures and documentation requirements. For instance, implementing single window operations to enable traders to submit documentation and data requirements through a single-entry point to all participating authorities will minimize the complexity of export, import, and transit formalities. This will facilitate the cross-border movement of goods in a consistent, timely, and efficient manner. Secondly, advance ruling or expedited clearance of time-sensitive, perishable products (like foodstuffs) before the arrival of the shipment at import location can effectively address the challenge of protracted waiting times at African borders and improve the consistency of food supplies on the continent. Thirdly, investments in expanding or enhancing transport infrastructure (roads, ports, bridges, and railways) can also curb excessive delays in moving goods within and across African borders.

Despite these findings, the following important two limitations are worth noting. First, due to data limitations, we relied on indicators of the ease of trading internationally in all goods (including food products). Further research is needed to understand the welfare effects of agri-food sector-specific trade facilitation reforms as data become available. Second, the beneficial effects of improved trade facilitation on food security are not straightforward. In this paper, we noted that it could be realized through several channels, including increased trade flows, better export and import prices, higher incomes, and



better employment avenues. However, in this paper, we do not examine these intermediary pathways. There is strong evidence that such welfare gains from trade facilitation initiatives exist. This paper demonstrates that policies to facilitate trade – through reductions in trade-related documentary burden and time costs – have the potential of improving food security outcomes in Africa.

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## Compliance with ethical standards

**Conflict of interest** The authors declared that they have no conflict of interest.

## Appendix

**Table 8** Definition of variables and data source

Variable	Definition	Source
Food security indicators		
Prevalence of undernourishment	Overall indicator of food security, measured as the percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life	FAO FSI
Average dietary energy supply adequacy	Indicator of food availability. It is an index of adequacy of food supply in terms of calories	FAO FSI
Depth of food deficit	Indicator of food access. It measures how many calories would be needed to lift the undernourished from their status, everything else being constant	FAO FSI
Access to improved sanitation facilities	Indicator of food utilization. It refers to the percentage of the population with access to improved sanitation facilities	FAO FSI
Trade facilitation indicators		
Documents to export	Number of documents required per shipment to export goods	WB DB
Documents to import	Number of documents required per shipment to import goods	WB DB
Time to export	Number of days necessary to comply with all procedures required to export goods	WB DB
Time to import	Number of days necessary to comply with all procedures required to import goods	WB DB
Cost to export	All the fees associated with completing the procedures to export a 20-ft container of goods in U.S. dollars	WB DB
Cost to import	All the fees associated with completing the procedures to import a 20-ft container of goods in U.S. dollars	WB DB
Trade disfacilitation index	Composite index of trade facilitation: first principal component of the above six indicators	Authors
Control variables		
Trade openness	Exports plus imports of goods and services as a percentage of GDP	WB WDI
Political stability	Political stability and absence of violence/terrorism	WB WGI
Agricultural productivity	Cereal yield (kg/ha)	FAO FSI
Population growth	Population growth (annual %)	WB WDI
Rural population	Rural population (% of total population)	WB WDI
Economic development	GDP per capita, constant 2010 US\$	WB WDI
Inflation	Annual percentage in the consumer price index, %	WB WDI
	Annualized anomalies of monthly temperature and rainfall realizations from their respective long-term averages divided by their respective	

**Table 8** (continued)

Variable	Definition	Source
Climatic shocks (temperature and rainfall)	long-term standard deviations (Jan. 1991 – Dec. 2015)	WB CC-KP
Instrument		
Distance to the frontier score	The gap between an economy’s performance and a measure of best practice	WB DB

FAO FSI denotes Food and Agriculture Organization’s Food Security Indicators; WB DB is World Bank Doing Business; WB WDI refers to World Bank World Development Indicators, and WB WGI means World Bank World Governance Indicators. WB CCKP is the World Bank’s Climate Change Knowledge Portal  
 Source: Authors’ Construct (2019)

**Table 9** List of sampled African countries

Algeria	Gabon	Namibia
Angola	Gambia	Niger
Benin	Ghana	Nigeria
Botswana	Guinea	Rwanda
Burkina Faso	Guinea-Bissau	Sao Tome and Principe
Cameroon	Kenya	Senegal
Cape Verde	Lesotho	Sierra Leone
Central Africa Republic	Liberia	South Africa
Chad	Madagascar	Swaziland
Comoros	Malawi	Tanzania
Congo	Mali	Togo
Côte d’Ivoire	Mauritania	Tunisia
Djibouti	Mauritius	Uganda
Egypt	Morocco	Zambia
Ethiopia	Mozambique	Zimbabwe

**Table 10** Principal component analysis of trade facilitation indicators

Component	Eigenvalue	Proportion explained	Primary variables	Eigenvectors	Correlation coefficient	Bartlett (p value)
Comp1	3.828	0.638	Number of documents to export	0.238	0.466	0.00
			Number of documents to import	0.313	0.613	
			Time to export	0.459	0.899	
			Time to import	0.470	0.920	
			Cost to export	0.451	0.883	
			Cost to import	0.457	0.894	

Comp1 represents the first principal component score, retained based on Kaiser criterion of eigenvalue greater than one. The correlation coefficients show the degree of correlation between the constructed composite index and the primary trade facilitation indicators. The *p* value of the Bartlett test of sphericity signals a rejection of the null hypothesis that the primary variables are not intercorrelated. *Source:* Authors’ computations

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