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Abstract

Food supply fluctuations remain a major challenge in Sub-Saharan Africa (SSA). In this regard, this study empirically examined the impact of agricultural productivity on food security stability in 37 selected countries in SSA from 1990 to 2016, using the pooled, least square dummy variable (LSDV), random and system generalized methods of moments (SYS-GMM) models. The study adopted per-capita food supply variability (PCFSV) as a measure of food security stability while agriculture value-added contribution to gross domestic product (AGVA) and crop production (CRPROD) were selected indicators of agricultural productivity. The LSDV and SYS-GMM model estimations revealed that agricultural productivity and the control factors contributed significantly, though with a mix of positive and negative effects, to food security stability in the selected countries in SSA during the period under review. The LSDV model showed that AGVA had no statistically significant positive effect on food security stability, however, this was corrected in the SYS-GMM model, but with a positive impact. The study concludes that stability in food security is achieved and sustained by improving agricultural productivity. Based on the findings, the study recommended that food security stability should be improved by enhancing agricultural productivity through ensuring effective implementation of pro-agriculture growth policies in SSA.

Keywords: Food Supply variability, Agricultural Productivity, Sub-Saharan Africa, Panel System GMM

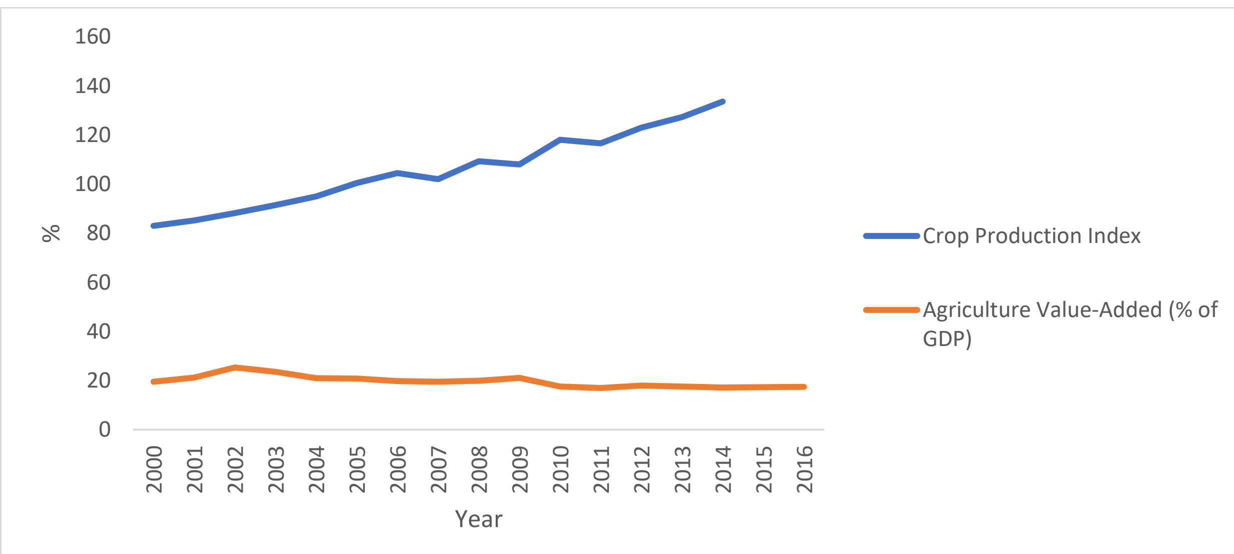
1. Introduction

Policy debates addressing the effect of agricultural productivity on food supply stability in a macro context are quite few in contemporary literature (Maxwell, 1996; Lang and Barling, 2012; Resnick et al., 2015; Fouilleux et al., 2017). This is in view of the fact that most countries in Sub-Saharan Africa (SSA) have been grappling with fluctuations in food supply, which has been a major barrier in the drive to fully achieve and sustain food security in the region (see Buhaug et al. 2015; Mvumi and Stathers, 2015). Food supply variations have intensified from the year 2000 (as depicted in figure 2 below) (FAOSTAT, 2017) and this ugly phenomenon has been linked to instability in agricultural output in the SSA region. The state of food security in an economy partly mirrors the level of agricultural productivity growth experienced. In view of this, effective agricultural policies aimed at ensuring sustainable food security level in SSA are crucial to poverty reduction and achieving significant economic growth (Collier and Dercon, 2014; Conceição et al., 2016). Sadly, SSA countries continues to trail behind other global regions in food security attainment (Wheeler and Von Braun, 2013; Porter et al., 2014: p 490; Hadebe et al., 2017).

Having evolved over time (Smith et al., 1993; Maxwell, 1996), the most recent concept of food security is defined as 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 (FAO, 1996; FAO et al., 2017: p 107). Food security defines a state relating to food supply and individuals' access to it, even as food insecurity situations can be severe, cyclical or momentary in nature. It is momentary when food is unavailable at a period, hence, can affect food production during periods of natural disasters and famine which results in low crop production and food scarcity. Similarly, political and economic issues hamper food accessibility while market instability leads to food price volatility crisis, causing momentary food insecurity (Eicher and Staatz, 1985). This is reflected in the occurrence of the food price hike between 2007 and 2009 which led to the price rise in international commodities that accentuated food insecurity and exacerbated poverty incidence in SSA (Minot, 2010; Minot, 2014; Timmer, 2017).

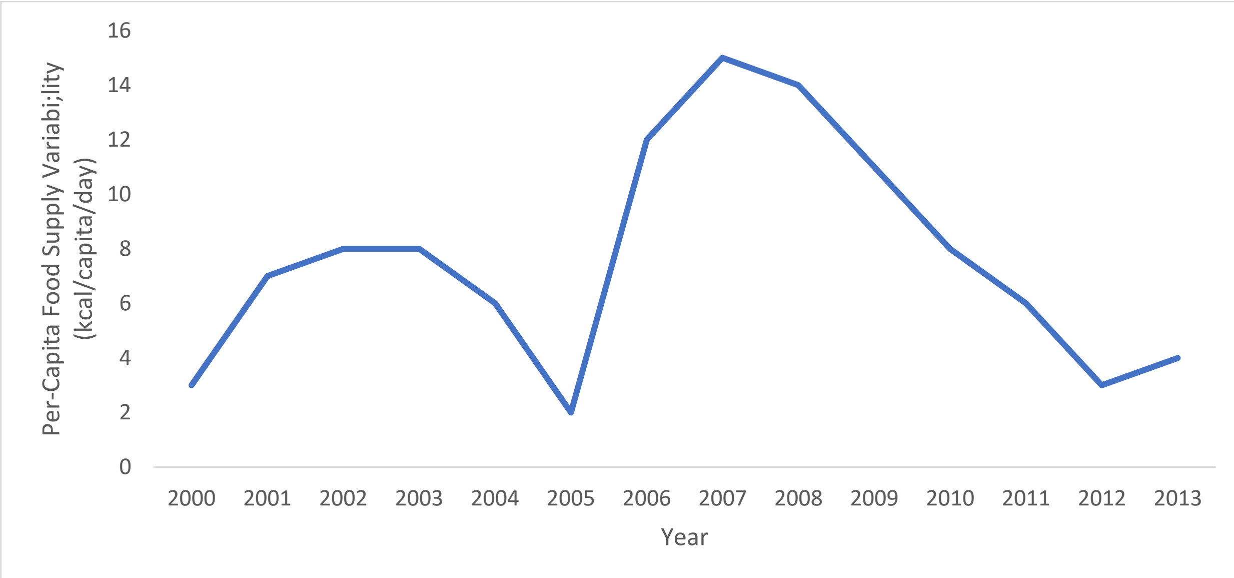
Food stability, which is the third measurement of food security, refers to the ability to access food over time and is a key determinant of global welfare. This explains why food policy discussions at the global level are beginning to focus on food stability (Grote, 2014; Timmer, 2014; Porter et al., 2014; Hendriks, 2015). Figure 1 below reveals a steady increase in crop production index in SSA from 83 in 2000 to 133 in 2014. Although the region seems to be experiencing crop production growth, per-capita food supply variation (measured in kilo calories) is still high, ranging from 3 kcal/capita/day in 2000, up to 8 kcal/capita/day in 2003, down to 2 kcal/capita/day in 2005, up to 15 kcal/capita/day in 2007, then down again to 3 kcal/capita/day in 2012, after which it began to rise slightly again, as shown in figure 2 below. While agriculture real value-added grew annually at about 4% from 1990 to 2013, its share of Gross Domestic Product (GDP) declined from 19.5% in 2000 to about 17% in 2016 in SSA (as seen in figure 1 below) (see Barrett et al., 2017). Maize production, which is a major staple food and accounting for about 30% of total cereal production in SSA, is still very relatively low, for instance, while its production in China, Indonesia and the United States has multiplied three-fold from 1960, from 1.8 tons /hectare to 6 tons/hectare, SSA yield has stagnated at below 2 tons/hectare, mainly due to climate variations (Cairns et al., 2013; Folberth et al., 2014).

Figure 1: Sub-Saharan Agricultural Productivity Indicators



***Source**: World Bank Annual Data; Author's computation*

Figure 2: Sub-Saharan Per-Capita Food Supply Variability



***Source**: FAOSTAT Data; Author's computation*

Some studies have discussed agricultural productivity under the concepts of total and partial factor productivity, examining the agricultural input to output ratio (Ndlovu et al., 2014; Capalbo and Vo, 2015; Helfand et al., 2015). Also, while certain studies have looked at the relationship between agricultural sector and economic growth in developing countries (Collier and Dercon, 2014; Keola et al., 2015), others have assessed the contributory role of agriculture in food production (Porter et al., 2014; Frelat et al., 2016), labour employment (McCullough, 2017; Palacios-Lopez et al., 2017) and food security (Webber et al., 2014) at the national and global level (Anderson and Strutt, 2014; Samberg et al., 2016). Similar literatures have also investigated the nexus among agricultural productivity, growth and poverty (Abro et al., 2014; Ozturk, 2017) while recent works are increasingly focusing on the impact of climate change on food security (Wheeler and Von Braun, 2013; Baldos and Hertel, 2014). In view of these studies, the significance of agriculture in securing food production has necessitated an investigation into how agricultural productivity impacts stability of food security in the SSA region. However, very few existing literatures (for example, Frelat et al., 2016 and Conceição et al., 2016) have dealt with the effect of agricultural productivity on food security in a cross-country case as SSA by adopting an empirical approach, as single-country studies seem to dominate this sphere of research (Baiphethi and Jacobs, 2009; Alpha and Fouilleux, 2017; Morioka and Kondo, 2017). Similarly, this study adopts agriculture value-added contribution to GDP and crop production in order to build on and relate our findings with regards to these studies mentioned above. Recent food riots resulting from occasional food crisis have also awakened the attention of policy makers to the importance of agricultural productivity in affecting the stability of food security in SSA, hence explaining the reason for the adoption of agricultural productivity as a factor in explaining food security in the Sub-African region (Berazneva and Lee, 2013; Wheeler and Von Braun, 2013).

This paper fills this gap by providing a more detailed empirical examination of the impact of agricultural productivity on the stability of food security in SSA. Within the purview of the authors' review on the subject, no empirical study has been conducted to combine both crop production (CRPROD) and agriculture value-added share of GDP growth (AGVA) in investigating the effect of agricultural productivity on food security stability in SSA, employing the static and dynamic System Generalized Method of Moments (SYS-GMM) panel estimation modelling techniques. The study considers agricultural productivity using crop production and agriculture value-added contribution to GDP indicators and how they influence per-capita food supply variability.

Agricultural productivity and food security stability are therefore pivotal in realizing sustainable economic growth. In this regard, the core objective of this study is to evaluate the impact of CRPROD and AGVA on food security stability among the selected countries in SSA. Accordingly, the sub-objectives are: (i) investigate whether food supply has been stable or fluctuating in SSA; (ii) determine whether agricultural productivity has a significant impact on food supply stability or not in SSA; (iii) analyze the nature, size and direction of relationship between agricultural productivity and food supply stability in the Sub-African region; (iv) examine whether the effect of agricultural productivity further enhances food supply variability or stability in SSA.
The rest of the study is structured as follows: Section 2 reviews existing similar literature to establish a nexus between the theoretical and empirical debates around the study. Section 3 examines the empirical framework. Section 4 analyzes and interprets the empirical result. Lastly, Section 5 concludes the study and recommends policy guidelines based on the outcome of the empirical result. The choice of selected SSA countries and period used in the study is subject to data availability.

2. Literature Review

2.1. Conceptual Review

Since the convening of the World Food Conference in 1974, in response to the global food price shock, the concept of food security had witnessed diverse evolving definitions. According to UN (1974), food security is ensured when global supply of staple food is always available to increase consumption and balance fluctuations or variations in production. In supporting the above notion, Heald and Lipton (1984) added that food security should guarantee stable access to food calories. While Barraclough and Utting (1987) views food security as a guaranteed state of food supply to the population to meet their nutritional demands, Falcon et al., (1987) adds that it ensures the dynamic accessibility of the populace in both short run and long run. Indeed, the stability dimension is buttressed in the concepts of Phillips and Taylor (1990) and UNICEF (1990), which argue that food security ensures reliable and adequate food supply throughout the year. The 2008 food price hike was a fall-out of a total decline in agricultural productivity, further worsened by export embargo adopted by many countries (Headey and Fan, 2008; Von Braun and Tadesse, 2012). The FAO (1996) adopted a robust and widely-accepted concept of food security, covering the components of food availability (adequate amount of healthy foods through domestic production, imports and food aid), accessibility (sufficient economic and physical resources for the population in purchasing necessary healthy food), utilization (provision of adequate energy and nutrients requirements for a healthy living) and stability (consistent, available and sustainable food supply always for the entire populace) (Pangaribowo et al., 2013; Berry et al., 2015; Sassi, 2015; Upton et al., 2016).

2.2. Theoretical Review

2.2.1 Food Availability Theory Approach

One of the oldest theoretical underpinnings of food security, particularly in the food availability approach, is the Malthusian theory, which examined the population-food symmetry. The theory summarily argues that population growth rate must not exceed food availability growth rate, hence this approach focuses on gross per-capita food production and supply (in case of a closed economy) and trade openness (in case of economy openness). Furthermore, this approach provided the underlying basis for the early concept of food security, as defined by (UN,1974), as the availability of sufficient global supply of food in sustaining a stable increase in food consumption and offsetting food production and price fluctuations. Two major policy recommendations stood out in this theoretical approach: (i) demand approach policy, which suggested a deliberate reduction in the population growth rate; (ii) supply approach policy, which proffered the option of enhancing per-capita food supply through agricultural production, hence signaling the advent of policies to boost agricultural productivity.

Within the macroeconomic policy framework, attention began shifting from agricultural productivity and food trade as major determinants of food supply (in)stability in a mono-sectoral economy, to macro-sectors at national, cross-country and regional economy level. This further led to the introduction of GDP, export and growth indicators. A major macro-framework, the Ricardian comparative advantage theory, which argued that each country should specialize in the production of a commodity in which it has comparative advantage over others, provided a framework for a cross-country food security policy analysis with a view to boosting total per-capita food production and increasing consumption (Burchi. and De Muro, 2016).

2.2.2. Income Theory Approach

The theory of Reutlinger and Selowsky (1976) was one of those which introduced the concept of GDP income in the food production literature under the Income approach. The approach viewed food insecurity, in terms of malnutrition, as an off-shoot of poverty, as such, it regarded government food policy intervention as a means of improving individual and household income earnings and ultimately, GDP and welfare of a country. Focusing on calorie supply shortage in developing economies in terms of income distribution, the theory examined a cost analysis of policy tools that could be employed in combating malnutrition. Although the study discovered that a rising per-capita income among all income classes, matched by gross per-capita income increase and per-capita food supply did not affect gross calorie shortage, there was a reduction in per-capita daily shortfall among the under-nourished. The study found that a situation of constant income distribution would necessitate increased food supply and demand growth to attain per-capita food consumption growth increase which would eliminate calorie shortfall among the poor. However, this state is only likely to be feasible when there is increased growth rates of food production, supply and consumption, made possible by fiscal subsidy interventions to stabilize high and low food prices to producers and consumers respectively. In a different approach, Pinstrup-Andersen et al. (1976) established a model in analyzing the nutritional consequences of commodity substitutes in agricultural research and policy in Columbia, by estimating the allocation of food supply expansion among different consumer classes, interrelated changes in gross food consumption and food security outcome. The literature submitted that a rise in gross nutrient supply is an insignificant variable in explaining the nutritional effect, even as consumer adjustment in gross food consumption is determined by the commodity where extra nutrients are sourced.

A similar study by Knudsen and Scandizzo (1982) examined the determinants of food security (calories) in developing economies through a macro-analytical estimation of the possible effect which income growth and reallocation have on elimination of undernutrition. The work employed a traditional demand analytical framework in modelling a food demand function by investigating the impact of calorie price variations, income and some control factors on cross-country calorie consumption distribution. It concluded that both expected food price rise and economic growth decline do not hinder food security outcome, provided the poor have access to other extra income sources (in case where traditional income distribution fails), necessary for them to attain a level of consumption threshold. Furthermore, the work of Dawson (1997), which adopted a pooled data of 41 developing economies, using per-capita income, income growth, distribution and certain control factors, analyzed the reaction of calorie consumption to income. It concluded that insufficient food consumption is a function of low economic development and not necessarily solely due to low income growth and distribution.

2.2.3. Entitlement Theory Approach

The Entitlement theoretical approach, developed in the early 1980s, gradually began to emphasize peoples' entitlement to access food, hence it considers hunger as a denial of accessibility to adequate food. One of the seminal works in this direction is Sen (1981), which focused on famine which occurred in India, Ethiopia and Bangladesh in 1943, 1973 and 1974 respectively. It canvassed a different approach to famine analysis (apart from food availability), which comprise trade openness, production and entitlement through government intervention, by engaging exchange entitlement strategies and instabilities, capable of resulting in significant changes in food distribution. The study also delved into the dichotomy between a reduction in food availability, which entails a country's gross food; and food entitlement, which deals with individual farmer's crop production. In a subsistence economy, crop failure would lead to a decline in both food availability and entitlement by subsistence farmers. As the farmer depends on his production for immediate food consumption with almost no ability to sell and purchase extra food, the main cause of hunger is tied to entitlement failure, instead of a reduction in market food availability. Accordingly, in the wake of a crop output failure of a peasant farmer, while others are not faced with a similar condition, there may be gross food supply while he goes hungry. Accordingly, if the farmer experiences crop productivity boost while others suffer loss, he is food-secure while others are undernourished. The study analyzed the divergent scenarios, including possibility of a simultaneous crop output loss occurrence, to illustrate that the determinant of famine is beyond food availability as a single factor, hence food aid policy in this direction might not be a sole effective panacea, rather, food entitlement.

2.2.4. Capability Theory Approach

Many economic production processes and developments are unsustainable, as believed in the sustainable livelihood thinking (SLT) approach, drawing out the issue of vulnerability, shocks and resilience as major reasons of unsustainability. The SLT framework views the state of a secure and sustainable rural household as the solution to poverty rather than the normal professionals in the urban areas (Chambers, 1987). From the perspective of Conway (1987:100-3)**,** a stable agricultural system is defined by an optimal mix of productivity (crop production per unit factor measured in income per hectare or gross production of goods at micro or macro level, in terms of calories); stability (consistent or steady productivity despite internal or external factors causing fluctuating or varying tendencies in the system); sustainability (capacity of an agricultural system to remain productive despite interrupting forces); and equitability (refers to the uniform productivity allocation of the agricultural system among individuals, households, nation or countries). One of the earliest studies in the capability theoretical approach, Dreze and Sen (1989) also focuses on the concept of security, which is emphasized in the third measurement of food security, stability, which is a component of the SLT framework. The study viewed the capability concept of food security as a principal integral factor of human development with long term stability dynamics.

In conclusion, the theoretical debates have remained inconclusive as to which is the best approach to achieve food security, even as there is not enough empirical analysis to substantiate the assertions in perspective of SSA. In view of this, we proceed to assess some empirical works relating to agriculture and food security in various climes.

2.3. Empirical Review

Many studies have examined certain factors affecting food security, for instance, Brigham (2011) revealed the importance of agricultural commodities' exports as an important factor in combating food insecurity in 17 selected SSA countries. Engaging a configurative comparative technique, the review maintains that agricultural export is only beneficial in SSA under certain conditional mix of agriculture contribution to GDP, labour productivity and food import. The author stressed that countries in SSA should take a holistic review of the earlier-highlighted factor before embarking on agricultural exports.

Dorward (2013) observed the global trend of instability in agricultural food prices amidst per capita food demands. The work analyzed the relationship between stable agricultural productivity and variation in real food prices among high and low-income countries. The agricultural productivity indicators used were Cereal Equivalent Productivity of Agricultural Labour, and Cereal Equivalent Land Yield; while Cereal Equivalent Productivity of Inorganic Fertilizer, and Food Expenditure Ratio were proxied for food security variation. The study stressed the need for improved agricultural labour productivity and low food prices as key catalysts for enhanced economic growth

Fischer et al. (2014) investigated the impact of crop yield on global food security using the Harvest Index (HI). The report forecasted that while increase in real food prices must be kept at a minimum of 30%, crop production growth should exceed 60% annually in order to ensure food stability from 2010 to 2050. It also submitted that crop yield trend must be incremental at over 1.1% annually and yield gap variations must be bridged to mitigate food instability risk. The empirical report strongly advocates significant expenditure in the areas of research and rural amenities, whilst strengthening the economic cropping system to guarantee food security. Using a static fixed and random panel model method, Di-Marcantonio et al. (2014) assessed the association among food production, economic policies and governance factors in 41 selected African countries. The analysis revealed that although agricultural factors boost food production, food aid and economic crisis have a negative relationship with food production

According to Sraboni et al. (2014), which considered the gender effect in Bangladesh by adopting the Agriculture and Body Mass Indices, the study concluded that women agricultural empowerment increases food calories' supply and improve dietary conditions in Bangladesh households. The research recommended the provision of an effective policy environment that encourages investment in women and girls as a positive approach towards bridging the gender gap in the country. In another analysis, Slimane et al. (2016) explored the nexus between foreign direct investment (FDI) and food security in 55 developing economies between 1995 and 2009 using a panel data analysis approach. Food availability and utilization indicators of food security were employed in the composite model. The result showed that FDI in different economy sectors have dissimilar impact on food security, for example, it was observed that while FDI in the agricultural and secondary sectors have a significant positive relationship, FDI in the service sector has a significant and negative relationship with food security in the countries reviewed. Warr (2014) opines that increase in total food supply reduces malnutrition in developing economies. However, the paper argued that while gross economic growth and poverty reduction are not sufficient conditions for enhanced food security, food price increase accelerates malnutrition. The study suggested effective policy formulation and implementation to stimulate agricultural productivity whilst keeping food prices as low as possible.

Another study by Brooks and Matthews (2015) investigated the link between trade openness and food security at a macro level, arguing that a country's openness to trade positively affects food security in the wake of trade regulation to protect the poor. The research recommended effective policy reforms which boost agricultural investments and enhance public protection to maximize trade benefits and minimize losses. Similarly, Sassi (2015) examined certain drivers of food insecurity in 40 selected Sub-Saharan countries, employing a spatial non-parametric methodology. The findings revealed a positive relationship among agricultural labour performance, GDP per capita, food aid and food security except arable land which exhibited a negative association among the countries in SSA. It was recommended that effective macroeconomic policies and programmes, institutional strengthening and integration at the SSA regional level are key to improving the condition of food security in the region. Frelat et al. (2016) examined the determinants of food availability fluctuations among over 13,000 households in 17 SSA economies and discovered crop production as a key factor of food availability. Employing farm household size and arable land factors, the report proved that agriculture was a major determinant of food availability among over 70% of households considered while market accessibility had a significant relationship. The study recommended diversification into off-farm income sources and multi-dimensional policy integration, instead of a sole focus on agriculture growth, as part of strategies to boost food security and reduce poverty in SSA farm households.

Adopting the system GMM method, Dithmer and Abdulai (2017) investigated the impact of trade openness on food security using a large cross-country dataset. In line with economic theory, the finding shows that economy openness to trade has a positive and significant relationship with dietary consumption, diversity and quality**.** Therefore, the authors recommended that polices supporting trade liberalization should be encouraged to improve food security. Ogundari and Awokuse (2016) also conducted an empirical investigation into the influence of agricultural productivity on separate food security indicators in 41 selected SSA countries between 1980 and 2009, employing a panel Generalized Methods of Moment (GMM) data method. The paper considered cereal production and agriculture value-added as proxies for agricultural productivity; while per-capita nutrient supply and per-capita total food available were proxied for food security. The analysis showed that both agricultural productivity factors have a significant positive relationship with both food security factors, hence the paper recommended policy formulation to boost research and development to expand agricultural productivity and improve food security in SSA.

In summary, the conclusions reveal mixed outcomes of the effect of different factors of agricultural productivity on food security in the countries reviewed above. It is also evident that studies on

SSA are sparse and the theoretical approach arguments remain inconclusive. In this regard, our study fills this gap by empirically building on these extant literatures to examine how crop production and agriculture value-added affect food supply stability in SSA.

3. Empirical Methodology

3.1. Model Specification

The model employed in this study is premised on the empirical framework of Reutlinger and Selowsky (1976), Knudsen and Scandizzo (1982) and Dawson (1997), using a panel data estimation. We proceed to model the level of food demand as it relates to per capita food supply variability as determined by measures of agricultural productivity with respect to crop production and agriculture value-added share of GDP; and control factors (degree of openness, age dependency ratio and income per capita). We engage a panel data for 37 SSA countries from 1990 to 2016.

Food demand in a country, i at time t, FD_{it}, depends on the total quantity of food supply from the market in a country, i, at a period, t, FS_{it}, given below as:

$$FD_{it} = f(FS_{it}) \tag{1}$$

The food supply, FS_{it} can be decomposed using simple supply and demand analysis in line with economic theory that a country exports (imports) food if local supply is greater (less) than population demand. Food supply, FS_{it}, therefore determines the equilibrium food utility, FD_{it}. Suppose the indicators of agricultural productivity (AP_{it}), which are (crop production ($CRPROD_{it}$) and agriculture value-added share of GDP, ($AGVA_{it}$), are determinants of food supply in a country, i, at time, t, the equation is given as:

$$FS_{it} = f(AP_{it}\colon CRPROD_{it}, AGVA_{it}) \tag{2}$$

The focus on our empirical study is on the association-ship between food security and agricultural productivity in SSA. However, as food security is an indicator of underdevelopment (see Dawson, 1994, p. 362), where the level of agricultural development is one aspect, we examine other factors of development that control for food supply. In line with Reutlinger and Selowsky (1976, p. 14) and Dawson (1994, p. 362), we consider degree of openness in a country, i, at time, t, $DOPEN_{it}$, age dependency ratio in a country, i, at time, t, $ADRA_{it}$ and income per capita in a country, i, at time, t, $GDPPC_{it}$. In this view, equation (2) becomes:

$$FS_{it} = f(CRPROD_{it}, AGVA_{it}, DOPEN_{it}, ADRA_{it}, GDPPC_{it}) \tag{3}$$

where $CRPROD_{it}, AGVA_{it}, DOPEN_{it}, ADRA_{it}$and $GDPPC_{it}$ have been earlier defined and f is the functional term.

We transform equation (3) into linearized logarithm form in a panel data as depicted below:

$$logFS_{it} = \alpha_i + logCRPROD_{it} + \ logAGVA_{it} + logDOPEN_{it} + \ logADRA_{it} + logGDPPC_{it}$$
(4)

We introduce μ_{it} to represent the unexplained random shock, not accounted in the adjustment process, which is the composite error comprising the country's particular component, π_i, the time component, ε_t and the idiosyncratic term, ∂_{it}. Therefore, we derive the below:

$$logFS_{it} = \alpha_i + logCRPROD_{it} + logAGVA_{it} + logDOPEN_{it} + logADRA_{it} + logGDPPC_{it} + \mu_{it} \quad (5)$$

The coefficient of apriori assumptions are highlighted thus: An increase in agricultural productivity is hypothesized to significantly improve food supply stability and reduce per capita food supply fluctuations in SSA**;** a rise in degree of openness of the economy is expected to enhance food supply stability in SSA through food exports when supply exceeds demand and food imports when demand exceeds supply; an increase in dependent to working group ratio is assumed to increase variability and result in decline in food stability level while increasing per capita income is hypothesized to increase per capita food supply stability since increasing purchasing earnings of a person is likely to increase food purchase, hence stimulating food production (see Sassi, 2015; Ogundari and Awokuse, 2016; Dithmer and Abdulai, 2017).

3.2. Estimation Technique

3.2.1. Dynamic Panel Model

The study adopts a dynamic panel analysis to determine the dynamics of per capita food supply in SSA. The significance of analyzing dynamics of macro food security in the Sub-African region is suggestive of the fact that food supply in the present year is a function of preceding year (FS_{it-1}), hence we can represent the relationship between food supply and the factors influencing it in a dynamic model system (see Ogundari and Awokuse, 2016; Dithmer and Abdulai, 2017). We introduce the lagged dependent variable into equation (5) to transform to a dynamic model as:

$$logFS_{it} = \alpha_{it} + logFS_{it-1} + logCRPROD_{it} + logAGVA_{it} + logDOPEN_{it} + logADRA_{it} + logGDPPC_{it} + \mu_{it} \quad (6)$$

In summary, we denote the Panel dynamic model in SSA below:

$$fs_{it} = \alpha_{it} + \varphi fs_{it-1} + \theta ap_{it} + \sum_{n=1}^{n} \beta_{in} v_{int} + \mu_{it} \quad (7)$$

fs_{it}, fs_{it-1}, ap_{it}, v_{int} represent the logs of FS_{it}, FS_{it-1}, AP_{it} and V_{int} respectively. fs denotes the vector of food security variable in SSA, which is per capita food supply variability(kcal/capita/day) (PCFSV); α_{it} is the vector of the constant term; fs_{it-1} is the lagged value of the dependent variable; ap_{it} is the vector of agricultural productivity in SSA, proxied by crop production ($CRPROD$) and agriculture value-added share of GDP ($AGVA$); v_{int} is the vector of factors controlling for food security in SSA; θ denotes the coefficient of agricultural productivity measures, with n, being the number of control factors; φ and β_{in} are the estimated parameters of the lag of food security and control factors respectively; i represents the number of countries in SSA considered in our review.

3.2.1.1. System-Generalized Method of Moments (SYS-GMM) Model

A major challenge encountered in the Ordinary Least Squares (OLS) estimating technique is that it fails to solve the endogeneity problem of the independent variables stemming from correlation between the lagged dependent factor and the residuals. The combination of the Least Square Dummy Variable (LSDV) model and the lagged dependent variable provides reaction from the previous or present shocks to the present dependent variable. This condition is accommodated in the Generalized Method of Moments (GMM) technique, as developed by Arellano and Bond (1991) and later by Arellano and Bover (1995). This dynamic system takes care of the temporal autocorrelation in the error term, hence avoiding spurious regression. The GMM technique, which, compared to the OLS method, can resolve the endogeneity and heteroskedasticity problems and improve the performance of estimators in a panel model (Headey, 2013).
Furthermore, this study engages the robust version of the System-GMM (SYS-GMM) estimating model modified by Blundell and Bond (1998), which is an improvement on the GMM approach, by the inclusion of the instrumental variables (IV), hence, our reason for the choice of the model. The advantage of the SYS-GMM over the GMM model is that it overcomes the challenge of weak IV arising in the GMM model, making them more dynamically efficient. It follows the assumption of exogeneity of dynamic constant correlation among endogenous variables and unobserved fixed effects, thus factoring the linearity function of the lagged IV at both level and difference. In this regard, the SYS-GMM estimator of the dynamic panel model is preferred above the linear or static model as it allows for causality via the IV by assuming there is no correlation among random shock in the present period error term, the lagged dependent variable and the present variable (Kunst et al., 2016).

3.3. Definition of Variables and Data Sources

This study adopts a panel data set on 37 countries in SSA from 1990 to 2013 for our empirical investigation. The data set on the dependent variable, per capita food supply variability (PCFSV) (kcal/capita/day) is sourced from FAOSTAT database (FAOSTAT, 2017). It refers to the variability in food supply in kcal per daily capita output. The explanatory proxies for agricultural productivity, crop production (CRPROD) index and agricultural value added (%GDP), are derived from the FAOSTAT database and World Bank Indicator (WDI) National Account data respectively. The crop production index indicates annual agricultural production using a base 2004-2006 period, comprising all primary crops produced in SSA while the agricultural value added, which is the contribution of agriculture to GDP, measured in %GDP, which is the net sectoral output and comprises forestry, fishing, crop and livestock production in SSA, is sourced from the World Bank Indicator (WDI) National Account data. The control variables are degree of openness (DOPEN), age dependency ratio and per capita income (GDPPC). The trade indicator is proxied by degree of openness (DOPEN), that is, percentage contribution of the ratio of total value of imports and exports of goods and services to GDP, which measures level of openness in the SSA economy. Age dependency ratio (ADRA) measures the ratio of dependents, which are people below 15 years or older than 64 years to the working-age population, which are those aged between 15 and 64 years. The per-capita income is the annual percentage rate of growth in GDP per capita of the selected countries in SSA in constant 2010 U.S. dollars. It is calculated as a ratio of gross domestic product to midyear populace. Data on DOPEN, ADRA and GDPPC are derived from the World Bank Indicator (WDI) National Account data (WDI, 2017).

In line with the capability theory explained above, per-capita food supply variability is deemed the most suitable food stability indicator, since our emphasis is on the influence of agricultural productivity on food supply variations (Dreze and Sen, 1989). Also, our adoption of food stability as food security measurement is premised on the assertion that agricultural productivity influences food supply through agricultural production dynamics (Ogundari and Awokuse, 2016). The focus on food stability is hinged on the theoretical belief that hunger is directly linked to food entitlement, which is also a function of crop production and ultimately, agricultural productivity (Sen, 1981). Our choice of this indicator relies on the definition of food stability, as ensuring consistent or steady food supply despite internal or external factors that cause fluctuating or varying tendencies in the food system (Conway (1987:100-3).
Crop production is a key significant indicator of agricultural productivity, as cereal grains constitute a bulk of crop produce in SSA while also accounting for the greater proportion of staple food diet and dietary energy supply, especially among the rural poor in the region (Cairns et al., 2013; Fisher et al., 2015; Beyene et al., 2016; Hadebe et al., 2017). The inclusion of dynamics of per capita income variable is because it can determine the purchasing capacity of each country resident for food purchase over a time period in SSA. Openness of the economy to trading activities control for the effect of the degree to which SSA countries are opened globally on food security measures. In line with economic theory, it is expected that an economy would import more food to supplement inadequate local supply while it would export food during periods of excess supply over demand (Dithmer, J. and Abdulai, A., 2017).

For the sake of our study, we consider 37 SSA countries due to data constraint which are: Angola, Benin, Botswana, Burkina-Faso, Cabo-Verde, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Nigeria, Republic of Congo, Rwanda, Senegal, Sierra-Leone, South Africa, Swaziland, Tanzania, Togo, Uganda and Zambia.

4. Data Analysis and Model Estimation

4.1. Summary of Panel Unit Root Test

We proceed to carry-out stationary tests by engaging the different robust unit root tests of Levin, Lin and Chu (LLC); Im, Pesaran and Shin (IPS) and the Augmented Dickey Fuller (ADF)-Fisher Chi-square. We adopt the three tests comparatively to substantiate the appropriateness of the panel data (Pesaran et al., 2001). The findings in Table 1 below show that all the variables become stationary after first difference (I(1)) as none of the series is stationary at level (I(0)) or after second difference (I(2)). Therefore, the unit root test result reveals that our data is stable and thus, justifies our adoption of the panel data variables in our research analysis.

Table 1: Levin, Lin & Chu; Im, Pesaran and Shin and ADF-Fisher Chi-square unit root tests

Variable	Levin, Lin & Chu Unit root test (individual intercept)		Im, Pesaran and Shin Unit root test (individual intercept)		ADF-Fisher Chi-square Unit root test (individual intercept)	
	Order of integration	P-Value	Order of integration	P-Value	Order of integration	P-Value
Per Capita Food Supply Variability	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***
Crop Production	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***
Agriculture Value Added	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***
Degree of Openness	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***
Age Dependency Ratio	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***
GDP per capita	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***

Source**: Authors' computation using E-views 9.5 Statistical Package. "" represents 1% significant level.*

4.2. Summary of Variable Statistics

It is necessary to illustrate an overview of the panel analysis of variables in the assessment of food security stability in SSA during the period of review, showing the mean, median, minimum, maximum, standard deviation, skewness, kurtosis statistical values. The panel variable statistical description depicts the annual distribution in logarithm structure.

The result in table 2 below displays the statistical performance of the factors affecting food security stability in SSA between 1990 and 2016. Per-capita food supply variability (PCFSV), as a proxy for food security, measures the stability of food supply in SSA; CRPROD and AGVA are respective indicators of crop production and agriculture value-added contribution to GDP which are the main regressors on PCFSV while DOPEN, ADRA and GDPPC are control proxies for degree of openness, age dependence ratio and per-capita income, in determining the level of food security in SSA.

The data statistical result indicates that the mean variable distribution in our study are all positive and showing statistical closeness to both minimum and maximum values. The mean distribution of per-capita food supply variability (PCFSV), crop production (CRPROD), agriculture value-added contribution to GDP (AGVA) and age dependency ratio (ADRA) at 3.515579, 4.520510, 3.000796 and 4.455313 respectively, are closer to the maximum compared to the minimum values. This suggests PCFSV, CRPROD, AGVA and ADRA variables display a good statistical performance and are expected to significantly influence food security stability during the period under review in SSA. Contrastingly, the mean distribution values of degree of openness (DOPEN) and per-capita income (GDPPC) at 4.223973 and 7.574431 respectively, are closer to the minimum than the maximum. This reveals that DOPEN and GDPPC may not display a good statistical performance and may not significantly impact food security stability in the period under study in

SSA. Furthermore, all the positive mean, median and standard deviation values are located within the range of the minimum and maximum values, indicating that the panel data exhibit significant distributional consistency. Also, the small standard deviation distribution shows the very little extent to which the panel data disperses from the mean values. The positively-skewed statistical distribution of DOPEN and GDPPC indicate their right-sloped long tail while the negatively-skewed PCFSV, CRPROD, AGVA and ADRA reveal their left-sloped long tail. Similarly, the kurtosis panel distributional values are all positive; while PCFSV, CRPROD and ADRA are greater than 3, showing leptokurtic densities with fatter tails, AGVA, DOPEN and GDPPC are less than 3, showing platykurtic densities and producing fewer outliers than the normal distributions. The probability values are all significant at 1% and 5% level, revealing there is a possible significant relationship between the explanatory factors and food security stability in SSA, hence, establishing the appropriateness of the panel model in the study. The descriptive statistical sample indicates 990 observations out of 999 expected observations in the panel data adopted.

Table 2: Description of Variable Statistics

	PCFSV	CRPROD	AGVA	ADRA	DOPEN	GDPPC
Mean	3.515579	4.520510	3.000796	4.455313	4.223973	7.574431
Median	3.555348	4.554561	3.255880	4.486724	4.202526	7.430731
Maximum	5.231109	5.426271	4.369983	4.688708	5.740935	9.956448
Minimum	1.098612	3.376563	0.709160	3.702545	2.979814	5.488943
Std. Dev.	0.625533	0.304431	0.831275	0.174491	0.418528	0.895402
Skewness	-0.441599	-0.277493	-0.894469	-1.873787	0.136827	0.585604
Kurtosis	3.436852	3.509884	2.836180	7.140781	2.729388	2.840047
Probability	0.000000***	0.000008***	0.000000***	0.000000***	0.047126**	0.000000***
Observations	990	990	990	990	990	990

*Source: Authors' computation using E-views 9.5 Statistical Package. "***" and "**" represent 1% and 5% significant level.*

4.3. Correlation Matrix Analysis

This section illustrates the nature of relationship and how the different pairs of variables correlate in the panel matrix system. Table 3 below depicts the positive, negative and strengths of association between the different pairs of variables, for instance, agriculture share of GDP (AGVA) and age dependency ratio (ADRA) show a positive but weak association with food security stability (PCFSV) at 0.095477 and 0.153638 while crop production (CRPROD), degree of openness (DOPEN) and per-capita income (GDPPC) exhibit a negative weak relationship with PCFSV, at -0.246840, -0.124700, -0.106410, respectively. The study also shows that DOPEN and GDPPC have a positive but weak relationship with CRPROD, at 0.142922 and 0.250093 while AGVA and ADRA have a negative weak relationship with CRPROD, at -0.080790 and -0.197420 respectively. The relationship between ADRA and AGVA is positive but weak, at 0.548712 while DOPEN and GDPPC are negatively and weakly associated with AGVA, at -0.450437 and -

0.737782 respectively. Both DOPEN and GDPPC are negatively and weakly correlated with ADRA, at -0.354803 and -0.639072. Lastly, GDPPC has a positive but weak relationship with DOPEN.

Table 3: Correlation Matrix Result

	PCFSV	CRPROD	AGVA	ADRA	DOPEN	GDPPC
PCFSV	1.000000					
CRPROD	-0.246840	1.000000				
AGVA	0.095477	-0.080790	1.000000			
ADRA	0.153638	-0.197420	0.548712	1.000000		
DOPEN	-0.124700	0.142922	-0.450437	-0.354803	1.000000	
GDPPC	-0.106410	0.250093	-0.737782	-0.639072	0.443022	1.000000

Source: Authors' computation using E-views 9.5 Statistical Package

The table 3 correlation matrix shows a mix of both positive and negative relationships between the different pairs of relationships considered, however, all the association pairs exhibit weak relationship as they are less than 80% threshold strength level, showing a very low possibility of serial correlation problem. As the result in table 3 above cannot be statistically relied upon to premise our conclusion on the relationship between the dependent variable and regressors, the study goes further to test among the pooled (OLS), fixed effect (LSDV) and random effect static regression models, which is best appropriate to adopt in our study, notwithstanding our earlier adoption of the dynamic panel model, in a bid to arrive at a broader and more robust result.

4.4. Pooled, LSDV Effect and Random Effect Regression Analysis

The pooled (OLS) regression analysis does not factor the heterogeneity or individuality existing in the pooled panel data. However, the fixed effect or LSDV model allows for heterogeneity or individuality among the variables in the panel data model via its intercept value. As the intercept may vary across the variables, it does not vary over time. The random effect model allows common mean intercept values for the panel data, thus assuming heterogeneity has a random nature and a component of the error term.

Table 4: Regression Results

Variable	Pooled Model		Fixed Effect		Random Model	
	Coefficient	P>/t/	Coefficient	P>/t/	Coefficient	P>/t/
C	3.671110	0.0000***	4.321864	0.0122**	3.818069	0.0062***
CRPROD	-0.480302	0.0000***	-0.258476	0.0019***	-0.350671	0.0000***
AGVA	0.039378	0.2705	-0.083434	0.1506	-0.073915	0.1420
DOPEN	-0.102943	0.0496**	-0.351004	0.0000***	-0.280486	0.0001***
ADRA	0.411274	0.0047***	0.665560	0.0206**	0.638373	0.0068***
GDPPC	0.066010	0.0672*	-0.114876	0.2160	-0.019868	0.7600
R-Square	0.078856		0.323153		0.091462	
Adj.R-Squared	0.074175		0.293880		0.086845	
	16.84731		11.03931		19.81172	

F-Statistics Prob(F-Statistics)	0.0000***	0.0000***	0.0000***

*Source: Authors' computation using E-views 9.5 Statistical Package; "***", "**" and "*" represent 1%, 5% and 10% significant level respectively variability*

Table 4 above provides a snapshot of the analysis of the pooled, fixed and random effect panel model on the level of food security stability in SSA. Crop production (CRPROD), degree of openness (DOPEN) and age dependency ratio (ADRA) are statistically significant in explaining food security variability (PCFSV) in the Sub-African region at 1% and 5% in all the three models, showing relative significant consistency with food security and agreeing with empirical expectation while per capita income (GDPPC) is only significant in explaining PCFSV in the pooled model. In line with our apriori expectation and agreement with Dithmer and Abdulai (2017), CRPROD and DOPEN have an inverse relationship with food security variability in all the regression models analyzed. Therefore, as SSA countries produce more crops and increase trading activities in the global arena, food supply variability or fluctuations reduces and food security stability is improved, as also supported by Slimane et al. (2016). Furthermore, ADRA has a positive effect on PCFSV, showing that as the ratio of dependent to working population increases, food security variability continues to rise and food stability is hampered in the African region, mainly due to economic burden on the working class. Contrary to our expectation, GDPPC has a positive relationship with PCFSV in the pooled estimation, though significant, hence as the income of citizens rises in SSA, food supply fluctuations rises and vice versa. Contrastingly, AGVA does not have significant effect on food supply variability in the three models in SSA, however, it has a positive insignificant association with PCFSV. In both the fixed and random static regression models, AGVA and GDPPC display negative coefficients, indicating that as agriculture contribution to GDP and income level rises, food supply stability is enhanced and food security improves in SSA, in line with Warr (2014) and Sassi (2015). However, SSA is yet to achieve significant food supply stability, despite increase in crop production and agriculture value-added annual growth (shown in figure 1). Sadly, this development can be attributed to low level of agricultural productivity in the region.

In summary, the F-Statistical probability values of the three models are all significant at 1% level, suggesting that all the models are appropriate to examine food security stability in SSA. However, only the fixed effect model has the highest adjusted R-Squared value at 29.3%, compared to pooled and random models at 7.4% and 8.6% respectively, hence implying the LSDV model is the most appropriate model but a further confirmation would be investigated, employing the Hausman and F-statistical tests.

4.5. Panel Regression Tests.

The Dummy Wald and Hausman tests are engaged to confirm the most appropriate regression model between the pooled and LSDV models; and LSDV and random models respectively.

4.5.1 Dummy Wald Statistical test

The Dummy Wald or F-statistical test handles the heterogeneity effect to decipher the uniqueness among the panel data intercepts which may affect the level of food security in SSA. The hypothesis is given as:

$Null\ Hypothesis$: H_0: Coefficients of Dummy variables = 0; Pooled effect model is appropriate.

$Alternative\ Hypothesis$: H_1: Coefficients of Dummy variables $\neq$ 0; Fixed Effect model is appropriate

Table 5: Dummy Variable Wald Test

Test Statistic	Value	Df	Probability
F-statistic	21.34563	(5, 948)	0.0000***
Chi-square	106.7282	5	0.0000***

*Authors' computation using E-views 9.5 Statistical Package; "***"represents 1%,*

The F-statistical value of 21.34 in table 5 above, has a probability of 0.0000, which is significant at 1% level, suggesting that we reject the null hypothesis, that the dummy coefficients are equal to zero and that the pooled effect model is inappropriate, thus, we accept the alternative hypothesis that LSDV model is the more appropriate model to adopt, since the dummy variable coefficients are not equal to zero. Hence, we conclude that the LSDV model is the more appropriate model to determine the impact of agricultural productivity on food security stability in SSA because it can capture the heterogeneity effect on food supply stability, unlike the pooled effect model.

4.5.2 Hausman Test

The Hausman test determines the most appropriate estimating model between the LSDV and random models (Hausman, 1978). The hypothesis for the appropriate model selection is given as follows:

$Null\ Hypothesis$: H_0: Random effect model is appropriate.

$Alternative\ Hypothesis$: H_1: Fixed Effect model is appropriate

Table 6: Correlated Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	12.045130	5	0.0342**

***Source**: Authors' computation using E-views 9.5 Statistical Package; "**" represents 5% significant level*

In line with the hypothesis highlighted above, we reject the null hypotheses and accept the alternative hypothesis due to the significant probability value (0.0342) at 1% level (P < 5%), as displayed in table 6 above. In this regard, we adopt the LSDV model as the most appropriate and efficient static regression model for examining the heterogeneity effect of agricultural productivity on food security among the selected countries in SSA. However, based on the limitations of the

OLS estimating technique which does not factor endogeneity in the model analysis, the study proceeds to employ the more efficient and robust SYS-GMM model (Headey. 2013).

4.6. Panel SYS-GMM Regression Analysis

The panel SYS-GMM reveals a more reliable conclusion on the impact of agricultural productivity on food security stability in SSA, by introducing the previous year value of food supply variability. It is expected that the lagged period of food supply stability or variability value influences current food security stability or variability period. The model is more efficient in achieving this objective as it can provide specification of dynamic panel data models with the LSDV model, as developed by Holtz-Eakin, Newey and Rosen (1988) and Arellano and Bond (1991**)**. It is also able to accommodate the cross-section of 37 SSA countries within the 27-year period under review. In our study, we lag the dependent variable by a year, which is the previous year period of per-capita food supply variability, as one of the regressors (PCFSV(-1)). The transformation innovation method applied is the first-order differential of the log of the explanatory factors. The dynamic panel data model is estimated using the two-step update weights GMM iterations with the time-series innovations that varies by cross-sections and the robust white period to compute the standard errors (Roodman, 2009a).

Table 7: Panel SYS-GMM Result

Total panel (balanced) observations: 888				
J-Statistic: 335.2223				
Prob(J-Statistic): 0.049100**				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PCFSV(-1)	0.712749	0.022401	31.81713	0.0000***
CRPROD	-0.351001	0.039525	-8.880555	0.0000***
AGVA	0.078960	0.038763	2.037002	0.0419**
DOPEN	0.046426	0.067728	0.685482	0.4932
ADRA	0.636991	0.377161	1.688910	0.0916*
GDPPC	0.246349	0.074874	3.290191	0.0010***

*Source: Authors' computation using E-views 9.5 Statistical Package; "***", "**" and "*" represent 1%, 5% and 10% significant level respectively*

The result illustrated in table 7 above indicate that all the independent factors (lagged per-capita food supply variability value (PCFSV(-1), crop production (CRPROD), agricultural sector contribution to GDP (AGVA), age dependency ratio (ADRA) and per-capita income (GDPPC)) are significant at 1%, 5% and 10% levels in influencing current state of food security stability (PCFSV) in SSA (Slimane et al., 2016), except degree of openness (DOPEN), which is insignificant in explaining food security stability in SSA. However, the previous year value of food security stability (PCFSV(-1), AGVA, DOPEN, ADRA and GDPPC have a positive effect on PCFSV while only CRPROD has a negative relationship with PCFSV, which also follows Warr (2014), that food security is improved more efficiently by expanding agricultural productivity through food production. However, this is contrary to the assertion made by Sassi (2015), that GDP per capita has a positive relationship with food security, as a strong income growth is crucial to meet the growing food demand in Africa. The positive relationship between AGVA and PCFSV, though in disagreement with our expectation, is in support of Frelat et al. (2016), which argues that agricultural growth does not solely determine food security but the driving of off-farm income generation**.**

This implies that predictions on the current level of food supply stability can be made based on the past year state of food stability in SSA, hence if there was an increased (decreased) supply of food in the previous year, it is most likely that food supply would also increase (decrease) in the present period. Contrary to our earlier assumption, as agricultural sector contribution to GDP increases, food supply fluctuations continue to increase in SSA. Also, contrary to our apriori expectation, as countries in the SSA region open their borders in the global arena, thus eliminating barriers to international trade, food supply variations continue to increase, contrary to Brooks and Matthews (2015) and Dithmer and Abdulai (2017), which argue that openness to trade supports food security. This is worsened by the vulnerability state of the SSA region to global risks and the subsequent discouragement of domestic production due to weak export. Also, as the ratio of age dependency to working population continues to rise, per-capita food supply fluctuations are enhanced and food insecurity is entrenched in SSA, showing that there seems to be over-dependence of the dependent populace on the working class. In the same vein, as per-capita income level rises, food supply variations also increase, which negates our apriori expectation and contradicts the study of Brooks and Matthews (2015), that low income levels are major causes of food insecurity. However, an expansion in crop production reduces fluctuations in food supply and ensures food supply stability, as argued by Ogundari and Awokuse (2016), that agricultural productivity positively and significantly affects food security in SSA.

4.7. Arellano-Bond Serial Correlation Test

One of the limitations associated with the GMM model is the possible problem of serial correlation, which invalidates the instruments and renders the findings unreliable (Baltagi, 2008). Although, the earlier correlation matrix result showed a very weak possibility of serial correlation presence, it is still pertinent to further test to validate and justify the usage of the model, using the Arellano-Bond serial correlation AR(1) and AR(2) test, as developed by Arellano and Bond (1991).

Table 8: Arellano-Bond Serial Correlation Test

Test order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	-9.367581	-91.721006	9.791322	0.0000***
AR(2)	-0.394323	-9.972511	25.290228	0.6933

*Authors' computation using E-views 9.5 Statistical Package; "***" represents 1% significant level*

Table 8 above displays the test outcome of serial correlation at AR (1) and AR (2). The guideline is that the SYS-GMM model has serial correlation at AR (1), which is the null hypothesis at AR (1) but the problem is corrected at AR (2), which is the null hypothesis at AR(2). Accordingly, the result agrees with the rule of thumb, as AR (1) probability is significant at 1% level, indicating the presence of serial correlation. Therefore, the null hypothesis at AR(1) is rejected while AR (2) is accepted at the probability value of 69.3%, signifying that the problem of serial correlation is now corrected at AR (2), hence, we accept the null hypothesis at AR (2), that there is no presence of serial correlation in the model. The SYS-GMM employed in this study passed the serial correlation test and further substantiates that the conclusion drawn from agricultural productivity effect estimation on food security stability in SSA is valid and reliable.

5. Conclusion and Policy Recommendations

This study focuses on the capability theoretical approach to food security and empirically examined the effect of agricultural productivity on food security stability in SSA by adopting the pooled effect, LSDV, random effect and two-step SYS-GMM modelling techniques, using annual data from 1990 to 2016. The pooled effect, LSDV and random effect static modelling estimates show that crop production (CRPROD), degree of openness (DOPEN) and age dependency ratio (ADRA) have significant effect on food security variability (PCFSV) in the Sub-African region, while per capita income (GDPPC) is only significant in explaining PCFSV in the pooled model. CRPROD and DOPEN have a negative effect on food stability, hence, an increase in crop output and global trading activities further enhances food supply stability in SSA. Also, the higher the ratio of dependent to working population (ADRA), the more food supply fluctuations continue to rise. Consequently, both Hausman and F-tests select the LSDV model as the most appropriate estimating technique in determining the effect on food security stability in SSA. Accordingly, the LSDV model reveals that one indicator of agricultural productivity (CRPROD) and two control variables (DOPEN and ADRA) significantly influence food security stability in SSA. In this model, AGVA and GDPPC do not significantly influence food supply stability, however, their insignificant effects are corrected in the SYS-GMM model. Thus, the study establishes that, under the LSDV model, expansion in crop production output, increase in agricultural sectoral contribution to GDP, opening of the domestic economy to global trade, reduction in age dependent population and increase in per-capita income level contribute positively to food security stability in SSA countries.

Furthermore, the study engages the more robust SYS-GMM dynamic model in investigating food security stability in the Sub-African region. The findings reveal that the previous year value of food supply variability (PCFSV(-1)), CRPROD, AGVA, ADRA and GDPPC significantly affect present level of food supply stability in SSA, except DOPEN. While PCFSV(-1), AGVA, DOPEN, ADRA and GDPPC have a positive relationship with PCFSV, CRPROD has a negative association with PCFSV. The implication of this result is that past-year food supply stability, increase in agricultural sectoral share of GDP, integration of the country into the global economy, decline in age dependent population and increase in per-capita income level also lead to increase in food security fluctuations in SSA. However, increase in crop output contributes in ensuring food security stability in the African region. The Arellano-Bond tests further justifies the efficiency and validity of the findings by establishing there is no serial correlation in the model. In summary, the LSDV and SYS-GMM models conclude that all the explanatory factors significantly influence food security stability, revealing a mix in the positive and negative effects on food security in SSA. This finding shows that boosting agricultural productivity is vital to achieving stable food supply in the region.

In view of the study findings, we argue that the stabilizing role of agricultural productivity is significant towards achieving food security in SSA. Consequently, we recommend that agricultural production should constitute an integral element of policy measures towards achieving sustained food security. Trade policies should be relaxed with a view to encouraging exports to encourage local production, while eradicating policies that distort trade and expose the SSA region to global production shocks (Dithmer and Abdulai, 2017). Policies bordering on modern farming technologies and research; and increase in expenditure to the agricultural sector are key to enhancing agricultural productivity and enhancing food production in SSA. It is therefore imperative that the fiscal authorities in SSA should ensure that these policy approaches to agricultural productivity are sustainably intensified. Governments in SSA should ensure that increase in agriculture contribution to GDP growth translates to stable food supply by increasing and encouraging investment in the sector (as also suggested by Fischer et al., 2014), instead of diverting resources to other sectors at the neglect of agriculture. This would further ensure that as producer income rises, they are ploughed back into the agricultural sector to further boost production. Also, governments should ensure that the dependent population is gainfully employed, particularly to avoid constituting an economic burden on the working population.

Finally, similar studies on agriculture and food stability can be extended further by using other indicators which may also appropriately determine the relationship. Also, research may still be carried out in SSA sub-regions such as West, East or Southern Africa to further substantiate if the subject-relationship conclusion in the SSA holds in the respective sub-regions suggested as well.

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