Agricultural Productivity, Fiscal and Trade Policies Nexus in Sub-Saharan Africa: A Panel Structural Vector Error Correction Model Analysis

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Abstract: Public expenditure on the agricultural sector targeted towards raising investments for increased agricultural productivity has been low in most countries in Sub-Saharan Africa (SSA). Also, existing empirical evidence on the impact of fiscal and trade policies on the improvement of agricultural systems remains mixed and inconclusive. In view of the above, this study employs a three-variable Panel Structural Vector Error Correction Model (PSVECM) in capturing the dynamic structure of the possible relationships among agricultural productivity, fiscal and trade policies in 37 selected countries within SSA, using annual data from 1990 to 2016. In imposing short- and long-run identifying restrictions, the cointegration structure of the PSVECM reveals an instantaneous impact of government expenditure and terms of trade on crop production in the transitory period. Likewise, terms of trade has a permanent significant effect on crop production and government expenditure within the reviewed period in SSA. The impulse response and variance decomposition analysis trace out a mixed result of both short and long run significant and fluctuating relationships among government expenditure, terms of trade and crop production in SSA. This finding implies that fiscal and trade policies are crucial in influencing agricultural productivity; and recommends that policymakers should adopt expansionary fiscal (in line with the Keynesian theory) and trade policies which stimulate both short and long run agricultural productivity growth in countries within SSA

1. Introduction

The theme of the 22nd African Union (AU) summit at its headquarters in Addis Ababa, Ethiopia that ended on 31 January 2014 was "Agriculture and Food Security". The central focus of that assembly was a commitment of African countries towards an Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihood which will come to be known as the 2014 Malabo Declaration at the end of the AU Summit that was held from 26-27 June 2014 in Malabo, Equatorial Guinea. The AU embarked in the drive of launching a set of concrete agricultural targets and reforms to harness opportunities for inclusive and sustainable development of its member countries. Premised upon the 2014 Malabo Declaration, many countries on the African continent have being reviewing, strategizing and setting macroeconomic policies in line with the Comprehensive African Agricultural Development Programme (CAADP) to achieve food security by 2025 (African Union, 2014 and Conceição et al., 2016). However, most countries in Sub-Saharan Africa (SSA) are still far behind from achieving the set and agreed-upon goals in the light of the regional macroeconomic environment. Global fall in agricultural prices has resulted in considerable exports earnings decline in SSA, of which agricultural raw materials constitute a bulk of total global output. This in turn has resulted in current account deficit in most countries in SSA, especially in Kenya, Côte d'Ivoire and Ghana. This has further worsened the SSA's regional external and domestic macroeconomic position, thus demanding an emergency feasible macroeconomic policy response (IMF, 2017).

In view of this, the motivation for this paper stems from the fact that agricultural productivity in SSA is characterized by different dynamic outcomes, which can be traced mainly to an increased trade openness and a series of fiscal policies and the accompanying structural policy reforms, in terms of reduced government spending that have implemented by many countries in SSA since the 1980s.

In SSA, fiscal policy is a potent instrument available to policymakers, involving the optimal combination of tax and government expenditure policies in achieving macroeconomic goals (Calderón and Nguyen, 2016). However, policymakers are constantly faced with an array of macroeconomic policy choices to consider in stimulating agricultural productivity, for example, whether adopting expansionary fiscal policy, resulting in increased public expenditure on the agriculture sector would be more suitable in increasing crop production; or if adopting a restrictive fiscal policy would stimulate both short and long-term investments and boosting trade exports in the agricultural sector.

Unfortunately, fiscal management has not resulted in increased aggregate agricultural production growth in SSA, compared to other global regions, causing increased food imports and decline in agricultural exports in the region (Smale *et al*., 2013). In view of this, it is crucial for policymakers to have an appropriate understanding of the influence of fiscal policies in determining fluctuations in agricultural productivity and particularly, crop production via government spending and trade channels.

Earlier studies relating to fiscal-trade policies and agriculture include the arguments of how fiscal-monetary policy mix influences farm productivity indirectly through fluctuations, wealth, costs and cash effects, see (Tweeten, 1983); and the significant effect of effective domestic trade and macroeconomic policies, particularly government expenditure, on agriculture productivity in South American developing economies, (Valdes, 1986). Extant literatures that have researched extensively on single country case studies include Thailand (Jaroensathapornkul and Tongpan, 2007), Romania (Cristea *et al*., 2014), Malaysia (Abdkadir and

Tunggal, 2015), Iran (Mehrabian, 2015), Ukraine (Shevchuk and Kopych, 2017), Kenya (Othuon and Oyugi, 2017) and Nigeria (Olarinde and Abdullahi, 2014; Tijani *et al*., 2015; Oluwatoyese and Razak, 2016).

Furthermore, studies that have been conducted on regional blocs include effect of trade and macroeconomic policies on agricultural growth in South America (Valdes, 1986) and European Union (Dritsakis, 2003). Research has also been conducted in the case of Africa (see Ojede *et al*., 2013; Mugera and Ojede, 2014) and Sub-Saharan Africa (Yu and Nin Pratt, 2011; Fuglie and Rada, 2013).
However empirical research examining the dynamic relationship between fiscal-trade policy nexus and agricultural productivity in the SSA region is still sparse. In the light of this, this study contributes to existing literature by filling this research gap. The core aim of this research is to determine how fiscal and trade policies impact agricultural productivity in selected SSA countries. Therefore, the study intends to achieve the following three sub-objectives:

(i) examine whether selected fiscal and trade variables significantly influence agricultural productivity in SSA or not in the short and long run;
(ii) estimate the nature, size and direction of the effect of fiscal and trade policy factors on agricultural productivity in the African sub-region;
(iii) determine the shock and variance decomposition components of the impact of fiscal and trade policies on agricultural productivity in SSA and determine whether they are significant or not.

The rest of the study is organized as follows: Section 2 discusses the growth trend of the agricultural sector in the fiscal and trade spaces in SSA. Section 3 reviews theoretical debates around the study. Section 4 assesses the divergent empirical literatures relating to the study. Section 5 examines the empirical methodological framework. Section 6 analyzes and interprets the empirical findings. Lastly, Section 7 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. Fiscal Policy, Trade Policy and Agriculture Growth in Sub-Saharan Africa

The role of the agricultural sector in boosting the Gross Domestic Product in SSA countries cannot be over-emphasized, as it sustains up to 80% of the labour force, thus contributing to about 30% in GDP growth and more than a third of exports in the region (Garrity *et al*., 2010). Annual growth of agricultural real value added (constant 2010 US$) in SSA has been steady at about 4% rate from 1990 to 2016 while its contribution to GDP reveals a decline from 24% in 1995 to 16% in 2016 (Barrett et al., 2017). Furthermore, the relevance of SSA agriculture output in the global arena is evident, as it constitutes almost 80% of global agricultural output. The peculiarity of the SSA region is such that over 60% of the entire populace dwell in the rural areas where about 90% of the poor live while up to 80% of these have their means of livelihood mainly supported by the agricultural sector (Alston and Pardey, 2014; Kanayo, 2014; Beegle et al, 2016; Oluwatayo and Ojo, 2016). Agricultural exports in the SSA region constitute mainly primary products in its raw form that are susceptible to global price volatility (Minot, 2014). Côte d'Ivoire, Ghana and Nigeria account for about 65% of global cocoa production while Sudan, Chad and Nigeria are responsible for the production of a large proportion of Gum Arabic. Cash crops such as cocoa and sesame seeds constitute the bulk of global exports from the region at 60% and 40% respectively (Schaffnit-Chatterjee, 2014). Therefore, any major structural change in global demand or supply of these products would impact significantly on the balance of payment position of these countries (Johnson, 2016). While crop production grew annually from 83% in 2000 to 133% in 2014, its share of Gross Domestic Product (GDP) declined from 19.5% in 2000 to about 17% in 2016 in SSA (Barrett et al., 2017). Maize production, which is a significant staple food and comprising almost 30% of entire cereal production in SSA, is still very relatively low, for instance, while its production in China, Indonesia and the US has multiplied three-fold from 1.8 tons /hectare to 6 tons/hectare in 1960, yield has stagnated at below 2 tons/hectare in the SSA region (Cairns et al., 2013).

The macroeconomic policy framework in SSA seriously portends a weakening agricultural sector in the region as waning fiscal earnings position continue to result in weakening macroeconomic conditions. Most countries in SSA are faced with increasing public debts in the face of swelling cost of borrowing to finance huge government expenditures, coupled with reducing fiscal earnings, particularly in Tanzania, Angola, Gambia and Lesotho. The huge cost of servicing rising public debts has also impacted on soaring private costs of borrowing, with an ensuing pressure on fiscal budget. In view of this, most fiscal authorities in SSA have been slow in terms of timely macroeconomic policy response to address the challenges of drought-impact (Cashin *et al.*, 2017), pest infestation, terrorism and political violence. The fiscal authorities in many countries in SSA have also attempted to consolidate on policy response by drawing on their reserves to finance crop production mainly through export to ensure enhanced and stable food supply, however this has adversely affected their external position, resulting in depleting revenues amidst increasing government expenditures. Unfortunately, policymakers in the SSA region are faced with the problem of slow and implementation delay in macroeconomic policy adjustments.

Sadly, SSA has the highest incidence of agricultural productivity decline globally (Yu and Nin-Pratt, 2011; Fuglie and Rada, 2013; Porter et al., 2014; Hadebe et al., 2017). Most countries in the SSA region are still plagued with low agricultural productivity and agricultural export decline. The contribution of agricultural sector to GDP growth has also continued to decline for more than two decades (Collier and Dercon, 2014; Hilson and McQuilken, 2014; Barrett *et al*., 2017). In view of the challenges highlighted above, the effective implementation of fiscal and trade policies as a panacea to dwindling agricultural productivity has continued to pose a huge challenge to policymakers in SSA. Therefore, what is paramount in this paper is the need for an empirical research to examine the relationship between fiscal, trade policies and agricultural productivity in order to boost crop production in the SSA region (Olarinde and Abdullahi, 2014 and Díaz-Bonilla, 2015).

3. Theoretical Arguments

Literature is replete with divergent theoretical opinions on which macroeconomic policy tools should be best employed in achieving sustainable economic growth, for example, one of the pioneering theories on government expenditure is known as the Wagner's law. The law of increasing state activity, propounded by Adolph Wagner, postulates that as the fiscal responsibility to increase the level of national investment increases, fiscal expenditure pattern would also mirror the increasing capacity. The theory posits that there is an obvious possibility of a change in government spending due to increased levels of national growth and expansion of current and new sectoral productivity. Wagner forecasted that an expansion in GDP income would lead to increase in the ratio of government expenditure to national income (Antonis et al., 2013).

In another perspective, the classicalists uphold the view that the type of fiscal-monetary policy mix adopted could either improve or hamper economic growth pattern (Blanchard, 2006). They believed that expansionary fiscal and monetary policies, and contractionary fiscal and monetary policies both engender and stifle economic growth respectively; while a policy mix would result in a constant growth rate. Contrastingly, the Neo-classicalists contend that government expenditure has a small impact on economic growth (Barro, 1990). The Keynesians opine that an increase in government expenditure results in growth increase. They further assert that money supply fluctuations stimulate interest rate fluctuations, which stimulates investment fluctuations, which finally impacts national output significantly. In line with the Keynesian viewpoint, certain studies have also affirmed the nexus between fiscal policy and economic growth in many countries, for example, Tijani et al. (2015) revealed that gross government expenditure on the agricultural sector has a positive significant effect on economic growth in Nigeria. However, studies which conflict with the Keynesian perspective have also demonstrated an inverse relationship between fiscal policy and economic growth (see Ramu and Gayithri, 2016; Hussain and Haque, 2017).

The Keynesian theory argues that aggregate government, firm and household expenditures have a very significant impact on total demand in an economy; and that firm decisions are mostly a result of poor macroeconomic policy choices which lead to reduction in total expenditure. Their belief is rooted in the fact that a free market economy does not have any self-regulating mechanism, hence a market collapse phenomenon requires government policy intervention, for example fiscal policy stimulus, to stabilize the economy and stimulate sectoral output growth (Auerbach, 2012).

The Keynesian theory argue that fluctuations in total demand have a significant short-run impact on real sector output and not prices. The theory affirms that the sticky nature of price fluctuations in consumption and government expenditure components result in output fluctuations. The Keynesian argument on the multiplier effect explains that output fluctuations is a result of multiple spending dynamics, for instance, if fiscal multiplier exceeds 1 dollar, then a government expenditure increase would lead to an output increase by the same amount exceeding 1 dollar. A key distinction in the Keynesians from other theories is their support for countercyclical compared to business cycle fiscal policy, that is, they argue that fiscal deficit expenditure financing has the capacity to create employment during recession.
Premised on these differing theoretical views, it is crucial to review empirical literature that have examined the impact of fiscal and trade policies on the agricultural sector.

4. Empirical Review

The work of Dritsakis (2003) is one of the few earlier studies investigating agriculture performance in the European Union (EU) macroeconomic environment in the short-run and long-run, using a monthly data from 1982 to 2000. Employing the multivariate cointegration model, the findings suggest a bi-directional association between the agriculture prices and macroeconomic factors in the region. The study argues that macroeconomic policy outcomes play a crucial factor in agriculture price stability in the EU. Jaroensathapornkul and Tongpan (2007) studied the impact of government expenditure on the agriculture sector in Thailand by employing a structural analysis. The analysis found that increase in government spending had a positive effect on food consumption, food export, food import, agricultural GDP and employment but a negative effect on terms of trade surplus. Yu and Nin Pratt (2011) examined agricultural productivity growth trend in 37 SSA countries between 1961 and 2006 by adopting the nonparametric Malmquist index. The study found that there was a significant growth in the SSA agricultural sector from

1984 to 2006 due to production efficiency, optimal use of input and a favorable fiscal policy influence, amidst huge tax burden and rapid population expansion challenges. Akhmad et al. (2012) researched on the effect of fiscal policy on agricultural growth in Indonesia in six-year period using a simultaneous equation model. The findings showed that government spending in the agricultural sector at the local government level significantly influenced agricultural GDP. Similarly, Nasrudin et al (2013) concluded that trade openness increased the significant positive effect of fiscal policy on agricultural productivity in the Indonesia, and that fiscal policy aids in reducing internal risk from global shocks to the economy. It concluded that optimum allocation of government spending and increased infrastructure spending are key to growing the agricultural sector. Oseni (2013) examined the impact of fiscal policy on five sectoral outputs (including agriculture) in Nigeria using a Multivariate Co-integration analysis over a 30-year period. The study discovered a long-run relationship between government spending and agricultural output; and canvassed for increased spending on the agricultural and industrial sectors to sustain growth in the Nigerian economy. Fuglie and Rada (2013) estimated a simultaneous equation model on 32 SSA countries using data between 1977 and 2005 and discovers that economy and trade policy transformations that increased prices and improved agricultural terms of trade, within the SSA region encouraged farmers to employ new innovative methods of enhancing agricultural productivity. From the findings, the research recommended doubling annual expenditure on agricultural research and macroeconomic policy structuring that increase farmers' earnings to boost agricultural productivity in SSA. Ojede et al. (2013), adopting the nonparametric Malmquist productivity index and generalized method of moments (GMM) modelling techniques between 1981 and 2001, looked at the effect of macroeconomic SAP policy structuring on agricultural productivity in selected African economies. The research shows a significant positive relationship between agriculture productivity and SAP policy effect, hence concluding that macroeconomic policy restructuring contributed to agriculture sector productivity growth in Africa. Olarinde and Abdullahi (2014) examined the short and long-run effect of macroeconomic policies on crop production in Nigeria using the Vector Error Correction Model from 19778 to 2011. The analysis showed a long-run association among agricultural production, government expenditure and agricultural credit. Furthermore, the result showed a decrease in agricultural production in response to government spending and interest rate shocks in both short and long-run; and that a significant variation in agricultural food production can be explained by government spending patterns. The report recommended expansionary fiscal policy to guarantee sustained food production in Nigeria. Odior (2014) adopted a dynamic modelling technique in examining the response of agricultural outcome to macroeconomic policy in Nigeria from 1970 to 2012. The analysis revealed that government spending had less significant influence on agricultural productivity within the reviewed period. It recommended effective policy formulation to develop the agricultural sector in the economy. Mugera and Ojede (2014) examined if there is technological efficiency improvement in the agricultural sector from 1966 to 2001 in Africa using Data Envelopment Analysis (DEA). Generally, the result revealed no indication of technological growth among the African Sub-regions, although efficiencies varied across all the countries reviewed. It recommended both private and public policy reforms that would ensure farmers maximize existing technology and increase production. Cristea *et al*. (2014) conducted a similar study over a 20-year period in Romania using a regression analysis and found that exchange and interest rates both have indirect and direct effects on agriculture GDP, while inflation only impacted in the long run. The study concluded that there is no bi-directional association between agriculture GDP and the macroeconomic factors considered, hence the statistical basis on which the macroeconomic effect on agriculture is analysed in Romania is unreliable. Abdkadir and Tunggal (2015) revealed a long-run association between certain macroeconomic factors and agricultural productivity in Malaysia. Using the Autoregressive-Distributed Lag (ARDL) model to analyze annual data from 1980 to 2014, the study finds that inflation, export and public expenditure have a short-run impact on agricultural productivity. It further adds that while only nominal exchange rate demonstrates a key long-run influence on agricultural productivity, other factors such as interest rate, inflation, money supply, export and public expenditure do not have any strong long-run influence on agricultural productivity. Manyisa et al (2015) modelled a comparative analysis of government expenditure on agriculture growth in South Africa and Zimbabwe using the Error Correction Model (ECM). The paper revealed that increased recurrent agricultural sector spending compared to capital expenditure was harmful to the growth of both countries and recommended increased gross agriculture spending in both countries. Mehrabian (2015) examined the impact of liquidity and government spending on agricultural investment in both short and long in Iran using the Auto Regressive Distributed Lag (ARDL) approach. The findings show a long-run relationship between government expenditure and agricultural investment and encouraged increased government spending to stimulate agricultural sector growth.

Okoh (2015) employed the ECM to examine the influence of fiscal policy on agricultural growth in Nigeria from 1981 to 2013. The result showed that while agricultural export tax did not improve agricultural productivity, value-added tax improved agricultural productivity during the reviewed period. It also found that gross government expenditure has a negative effect on agricultural development; and that government expenditure on the agricultural sector has not succeeded in growing the sector because it had no direct effect on local farmers. The study recommended effective management of public agricultural spending and reduced agriculture export tax to support increased local agricultural production in the economy. Osinowo (2015) studied the effect of fiscal policy on sectoral outputs in Nigeria using the ECM from 1970 to 2013. The model analysis revealed that fiscal policy significantly improved all sectoral outputs except the agriculture sector. The study recommended eliminating unnecessary spending and fiscal policy restructuring to improve the sectoral productivity in Nigeria. Matthew & Mordecai (2016) explored the effect of national debt on agriculture productivity in Nigeria, employing the ECM technique on an annual data from 1985 to 2014. The result shows a long-run link running among domestic debt, interest rate and government agriculture expenditure on agricultural productivity. While the Johansen co-integration test deduces a major positive effect of local debt on agriculture production, the ECM demonstrates an insignificant positive influence on agricultural production. Furthermore, the result establishes a significant negative interest rate effect on agricultural productivity while government agriculture expenditure does not hold any key variable influence in explaining agriculture productivity growth in the country. According to the study, increase in national debt should be supported and macroeconomic policies should be effectively implemented with a view to ensuring a low and stable interest rate, hence stimulating agriculture productivity growth.

Shevchuk and Kopych (2017) modelled the fiscal policy effect on agriculture and industrial sector outcomes in Ukraine using the Structural Vector Autoregressive methodology from 2001 to 2016. The findings revealed a positive impact of government expenditure on both agriculture and industrial productivity but a negative short-run externality from the agricultural to the industrial sector. It recommended increased government spending on both sectors to grow production. Othuon and Oyugi (2017) examined the effect of fiscal, monetary and trade policies on agricultural production growth between 2005 and 2016 in Kenya using the Ordinary Least Square regression analysis. The study found that public expenditure, money supply and interest rates significantly influenced agricultural productivity and recommended increased spending to develop the agricultural sector.

The mixed conclusive results in the reviewed literatures further underscore the need to conduct an empirical analysis on the dynamic relationships among fiscal-trade policies and agricultural productivity in SSA.

5. Research Methodology

Most studies that have investigated the relationship between fiscal-trade factors and agricultural productivity have used different techniques in a time-series approach, for example, ARDL (Abdkadir and Tunggal, 2015), ECM (Manyisa et al, 2015) and Multivariate Co-integration approach (Oseni, 2013; Oluwatoyese and Razak, 2016). In a different approach, other similar studies have engaged different model techniques in panel data studies, such as, Multivariate Cointegration Technique (Dritsakis, 2003), Non-Parametric Malmquist productivity index and GMM model (Ojede *et al*., 2013), Data Envelopment Analysis (Mugera and Ojede, 2014). Other studies have also adopted the VECM (Olarinde and Abdullahi, 2014) and SVECM (Brüggemann *et al*., 2003; Jang and Ogaki, 2004; Karim *et al*., 2012) in a time-series approach.

This research seeks to examine the dynamic relationships among fiscal, trade policies and agriculture productivity in SSA, engaging a P-SVECM method. In line with certain studies which researched on agricultural productivity using a panel approach, for instance, Africa (Ojede *et al*., 2013; Mugera and Ojede, 2014), European Union (Dritsakis, 2003) and Sub-Saharan Africa (Yu and Nin Pratt, 2011; Fuglie and Rada, 2013), this study adopts a similar pooled cross-sectional data analysis in the case of most SSA countries. In view of the highlighted empirical procedures above, it is striking to note that, within the purview of the authors' knowledge review on the topic under study, no research has been conducted to examine a cross-country case study of SSA using the P-SVECM. In this regard, this research adds to extant empirical literature by engaging the P-SVECM in investigating the interrelationships between fiscal, trade policies and agricultural productivity in SSA.

5.1. Panel Structural Vector Error Correction Model

The Vector Auto-Regressive (VAR) model, developed by Sims (1980), employed in macroeconomic estimations, came as an improvement over the earlier-adopted larger equation models in the 1970s, which could hardly explain the robustness of the dynamic system associations in a panel or time-series data trend. Also, the traditional larger models were formulated based on the exogeneity-biasedness of the authors' discretions instead of being supported by economic theories. However, the VAR models considered the endogenous variables as apriori, which accounted for dynamism in the relationship among the variables that are determined by impulse responses and variance decompositions. In view of this, the SVAR model was later introduced to ascertain the shocks or innovations and impulse responses which revealed the interactions among the variables. The observation of the possibility of occurrence of spurious regression by Granger and Newbold (1974) brought the nature of the variable characteristics under statistical focus, thus emphasizing the importance of stochastic trends and stationarity positions with a view to avoiding distorted inferences. This later resulted in the notion of cointegration which can factor the dichotomy between short-run and long-run stochastic dynamics in a model framework built on economic theories (Granger, 1981; Engle and Granger, 1987; Johansen, 1995). Hence, the short-run and long-run interactions are appropriately integrated in the VECM structure, which also accommodates individual shocks with temporal and permanent impacts, capable of capturing impulse responses. Furthermore, the SVECM was introduced by King *et al*. (1991) (Breitung *et al*., 2004 and Liitkepohl, 2006).

Chen (2012) employed a P-VECM approach in assessing the nexus between energy consumption and economic growth in China. Ouma *et al*. (2016) also adopted the P-VECM technique in determining the relationship between agricultural trade and economic growth in the Eastern African region. In a different approach, Jiang and Liu (2014) examined the effect of construction demand on economic factors using panel cointegration analysis in three Australian regions. In line with these studies, this paper also adopts the Panel Vector Error Correction Model (P-VECM) analysis to model a Panel Structural Vector Error Correction (P-SVECM) framework in the case of SSA. This is premised on the reason that the P-SVECM framework is similar to that of P-VECM, given that the variables are endogenous and the interactions among them are in expected *apriori* based on economic theory (Granger and Newbold, 1974). Also, P-SVECM can effectively reveal the short-run and long-run dynamics among the variable relationships, in addition to providing a more suitable analysis of the parameters in a restricted pooled data approach. Consequently, the P-SVECM is constructed based on similar modelling pattern as the traditional P-VECM, apart from the introduction of the structural restrictions to the cointegrated variables, which is applied to the P-VECM in order to form a P-SVECM, hence depicting the model as a more robust technique in analyzing fiscal and trade policy transmission and in our case study, its effect on agricultural productivity in SSA. In the light of the concept of the P-SVECM explained above, our justification for the adoption of this model is based on four main reasons: (i) it allows short-run dynamic interactions among cross-sectional variables; (ii) it accommodates the impact of a cross-sectional temporary long-run equilibrium error on other panel data variables (Anderson *et al*., 2006 and Liitkepohl, 2006); (iii) it is able to efficiently estimate the restricted VAR model, allowing for a more appropriate estimation of impulse responses and variance decompositions; (iv) it aids the imposition of contemporaneous structural shock restrictions on the variable cointegrations which encompasses the variety of identifying suppositions, adopted in structural impulse response estimations (Liitkepohl and Reimers, 1992b).

In view of the benefits of the P-SVECM framework highlighted above, this study would effectively examine the relationship among fiscal, trade policies and agricultural productivity in SSA, while being confident that the findings based on the model estimations and analysis can be relied upon.

5.2. P-SVECM Model Specification

Following King et al. (1991) and Liitkepohl (2006), this study employs the P-SVECM estimate approach in analyzing the nexus among fiscal, trade policies and agricultural productivity in 37 countries in SSA, using three endogenous variables, which are: crop production (CRPROD), government expenditure (GOEX) and terms of trade (TEOT). We denote the SSA macro-economy in the panel structural model below:

$$\Delta V y_{i,t} = \delta_i d_t + \alpha\beta' y_{i,t-1} + \Gamma_1 \Delta y_{i,t-1} + \cdots + \Gamma_{p-1} \Delta y_{i,t-p+1} + W u_{i,t}; \qquad t = 1, 2, \ldots, \tag{1}$$

where Δ denotes the first difference in the variable; V is an invertible ($k \times k$) matrix describing the contemporaneous relationship among the endogenous variables; $y_{i,t}$ is a k-dimensional vector of the variables; δ_i is a ($k \times 1$) matrix of parameters representing country-specific intercept terms; d_t is a vector of deterministic components, hence $\delta_i d_t$ denotes the deterministic component of the model; α and β are ($k \times k$) adjustment and cointegration matrices of rank r respectively. More precisely, β is the cointegration matrix and r is the cointegrating rank of the process. The term $\alpha\beta' y_{i,t-1}$ refers to the error

correction term. The Γ_j's, $j = 1, \ldots, p - 1$, are $(k \times k)$ short-run coefficient matrices. W is a $(k \times k)$ matrix whose non-zero diagonal elements allow for direct effects of some shocks on more than one endogenous variable in the system and $u_{i,t}$ is a white noise error vector with mean zero and nonsingular covariance matrix: $\Sigma_{u_{i,t}}$, $\varepsilon_{i,t} \sim (0, u_{i,t})$. Moreover, $y_{i,t-p+1}, \ldots, Y_0$ are assumed to be fixed initial conditions.
In line with Johansen (1995) Gaussian Maximum Likelihood (ML) procedure, if the lag order $p-1$ and the cointegrating rank r, as well as structural identifying restrictions are given, the estimation of a PSVECM can proceed by first estimating the reduced form parameters in equation (1).

Suppose $X = (\Gamma_1 + \ldots + \Gamma_{p-1})$ and $T_{i,t-1} = [\Delta y_{i,t-1} + \ldots + \Delta y_{i,t-p+1}]$, then

$$XT_{i,t-1} = \Gamma_1 \Delta y_{i,t-1} + \cdots + \Gamma_{p-1} \Delta y_{i,t-p+1} \tag{2}$$

The PSVECM in equation (1) can be written compactly as:

$$\Delta V y_{i,t} = \delta_i d_t + \alpha \beta' y_{i,t-1} + XT_{i,t-1} + W u_{i,t}; \qquad t = 1, 2, \ldots, \tag{3}$$

where $y_{i,t}$ is the $(nx1)$ vector of endogenous variables given by:

$$yit = (CRPROD, GOEX, TEOT) \tag{4}$$

Impulse responses are often used to study the relationships between the variables of a dynamic model such as in equation (3). In other words, the marginal effect of an impulse to the system is traced out over time. The residuals $u_{i,t}$ are the 1-step ahead forecast errors associated with the PSVECM in equation (1). Tracing the marginal effects of a change in one component of $u_{i,t}$ through the system may not reflect the actual responses of the variables because in practice an isolated change in a single component of $u_{i,t}$ is not likely to occur if the component is correlated with the other components. Hence, to identify structural innovations which induce informative responses of the variables, orthogonal impulses, shocks or innovations are usually considered.

Following Liitkepohl (2006), the PSVECM model in SSA countries can be represented as given below:

$$y_t = \Xi \sum_{i=1}^{t} \vartheta_i + \Xi^*(L)\vartheta_t + y_0^* \tag{5}$$

where $\Xi = \beta_\perp \left(\alpha_\perp' \left(I_k - \sum_{i=1}^{p-1} \Gamma_i\right) \beta_\perp\right)^{-1} \alpha_\perp'$; $\Xi^*(L) = \sum_{j=0}^{\infty} \Xi^*{}_j L^j$ is an infinite-order polynomial in the lag operator with coefficient matrices $\Xi^*{}_j$ that go to zero as $j^{\rightarrow\infty}$. The term y_0^* consists total initial values. Notice that Ξ has rank $K - r$ if the cointegrating rank of the system is r. It depicts the long-run effects of the error impulse response, but $\Xi^*{}_j{}'s$ contain temporary effects.

Impulse response analysis is conducted to examine the dynamic relationship between the variables as in equation (3). The methodology adopted is in line with King et al. (1991) and Liitkepohl (2006), which indicates the reduced form model. The study identifies two steps in analyzing the PSVECM. Firstly, the cointegration rank (r) in the PSVECM model is defined. Secondly, the structural shocks of the PSVECM would be recovered by imposing sufficient identifying restrictions.

Considering our study, with $k = 3$ variables, and $r = 2$, this indicates that a maximum number of two shocks may have temporary impacts. Thus, there would be only one permanent shock $(k^* = K - r)$ in the model. The permanent shocks are hence identified by restricting the long-run impacts of the last two structural shocks in the model to zero (King et al., 1991). As $k^* = 1$, the permanent shock would be specified without further suppositions $(k^*(k^* - 1)2 = 0)$. For identification of the temporary shocks, $r(r-1)/_2 = 1$, further restriction is required (Gonzalo and Ng, 2001).

The identification of short run (A) and long run (ΞA) impact matrix is depicted as:

$$A = \begin{bmatrix} * & A_{12} & 0 \\ A_{21} & * & A_{23} \\ A_{31} & 0 & * \end{bmatrix} \begin{bmatrix} \gamma_{i,t}{}^{CRPROD} \\ \gamma_{i,t}{}^{GOEX} \\ \gamma_{i,t}{}^{TEOT} \end{bmatrix}; \ \Xi A = \begin{bmatrix} * & 0 & 0 \\ 0 & * & \Xi A_{23} \\ \Xi A_{31} & \Xi A_{32} & * \end{bmatrix} \begin{bmatrix} \gamma_{i,t}{}^{CRPROD} \\ \gamma_{i,t}{}^{GOEX} \\ \gamma_{i,t}{}^{TEOT} \end{bmatrix} \tag{6}$$

where, * denote unrestricted elements. A third restriction is placed on matrices, A and ΞA, and thus we have a total of $K(K-I)/_2$ or 3 independent restrictions as required for just-identification. In both matrices, the non-zero elements, $A_{\alpha\beta}$ and $\Xi A_{\alpha\beta}$ reveal that there are instantaneous impacts of factor α on factor β in the transitory and permanent periods respectively; with crop production, government expenditure and terms of trade representing the first, second and third equations respectively. The recursive nature of the transitory shocks in A matrix, A_{21} and A_{31} is assumed such that crop production responds instantaneously to a sudden change in government expenditure and terms of trade respectively. Equation A_{12} depicts that government expenditure responds to an instantaneous variation in crop production in the short run. Equation A_{23} indicates that terms of trade responds to an instantaneous change in government expenditure in the transitory period. (see Corsetti and Miiller, 2006; Kehoe & Ruhl, 2008; Funke et al, 2008; Dias and Dias, 2013, Clancy et al., 2014).

The recursive characteristic of the permanent shocks in ΞA matrix, $\Xi A_{31}$and ΞA_{32} is assumed that terms of trade has a permanent shock impact on crop production and government expenditure respectively. Equations ΞA_{23} assumes that terms of trade responds to a long run instantaneous effect of government expenditure in the matrix (see Müller, 2008; Konstantakopoulou, 2018).

5.3 Definition/Justification of Variables and Data Sources

The study employs a panel data spanning from 1990 to 2016 within 37 countries in SSA. The choice of selected SSA countries and period used in the study is subject to data availability. Crop Production (CRPROD) indicates annual agricultural production using a base 2004-2006 period and comprises all primary crops produced in SSA. It 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; Olarinde and Abdullahi, 2014; Hadebe et al., 2017).

General government final consumption expenditure (GOEX) includes all government current expenditures for purchases of goods and services. The choice of the use of government expenditure as a fiscal policy instrument is that it is able to influence economic welfare through money circulation, increased investment and reduced tax averseness with the overriding objective of promoting long-term agricultural productivity in SSA (Akhmad et al. 2012; Oseni, 2013; Odior, 2014 and Mehrabian, 2015). Terms of trade (TEOT) index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000. The use of this variable is in line with the studies of Jaroensathapornkul and Tongpan (2007), Nasrudin et al (2013), Fuglie and Rada (2013), Othuon and Oyugi, 2017) and Schmitt-Grohé and Uribe, 2017), which show the significance of terms-of-trade shocks in determining GDP fluctuations in poor countries, as the robustness of this variable is able to capture the relative price of a country's exports in terms of its imports. The choice of these three variables follows the studies of Jaroensathapornkul and Tongpan (2007), Nasrudin et al (2013), Abdkadir and Tunggal (2015), Okoh (2015) and Shevchuk and Kopych (2017), which also used government expenditure and terms of trade to measure the impact of government expenditure on agricultural productivity.

Data on CRPROD is derived from the Food and Agriculture Organization Statistical database (FAOSTAT, 2017) while the data on TEOT and GOEX are derived from the World Bank Indicator (WDI) National Account data (WDI, 2017). SSA countries are developing countries geographically located in the part of the African continent that lie south of the Sahara. 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.

6. Empirical Findings

This section examines the results of the Unit Root, Johansen Co-integration test, Lag length test, Impulse Response and Variance Decomposition analysis.

6.1 Panel SVECM Unit Root Test

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
Crop Production	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***

Government Expenditure	I(1)	0.0000***	I(1)	0.0000***	I(1)	0.0000***
Terms of trade	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.*

Table 1 reports the results of the unit root test of the Augmented Dickey-Fuller. As can be seen, all logged variables in their logged forms, LCRPROD, LGOEX, and LTEOT are not stationary at the level form. However, after first differencing, all the variables are stationary at least at 1 percent significant level. Since all the variables are I(1), the study proceed with the examination of the long run relationship between the variables in the VAR model. The optimum lag in the VAR model is 1 which is selected based on Schwarz (SC) and Hannan-Quinn (HQ) information criteria.

The result of the Johansen cointegration test is presented in Table 2. As indicated by Trace (Panel A) and Max-Eigen statistics (Panel B), there exist two cointegrating equations. This indicates that, there is a long run relationship between LCRPROD, LGOEX, and LTEOT.

Figure 1: Johansen Cointegration Test

Johansen Fisher Panel Cointegration Test
Series: CRPROD GOEX TEOT
Date: 07/11/18 Time: 14:53
Sample: 1990 2016
Included observations: 999
Trend assumption: Linear deterministic trend (restricted)
Lags interval (in first differences): 1 1

Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	568.9	0.0000	364.2	0.0000
At most 1	302.7	0.0000	216.9	0.0000
At most 2	236.5	0.6754	236.5	0.6754

* Probabilities are computed using asymptotic Chi-square distribution.

6.2 Lag length test

The study would adopt an annual panel data to test for the optimal lag length in selecting the best model. Conventional lag selection criteria such as Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn information criterion (HQ) information criteria tests were conducted while the AIC selected an optimal 1-lag length model, which is the automatic lag selection with the lowest value for the PSVECM. Accordingly, the lag 1 model is adopted by the study to reveal a reliable short and long-term analysis without restricting the large sample size which could negatively affect degrees of freedom and also avoiding the problem of serial correlation among the residuals. This procedure follows the studies of Karim *et al*. (2012), Olarinde and Abdullahi (2014), Jiang and Liu (2014), Oluwatoyese and Razak (2016) and Ouma *et al*. (2016).

6.3 Impulse Response Analysis

Figure 2 depicts the results of panel structural VECM impulse-response of agricultural productivity to a one standard deviation shock in government spending in SSA. CRPROD responds positively to its own standard deviation shock up to 10 years, for example, 1 percent shock in CRPROD leads to an increase in its own positive shock by 0.14 percent within six months and gradually decreases to zero after a year and six months. However, from then, CRPROD experiences high fluctuations both in the short and long-run periods. It continues to fluctuate, though positively to its own standard deviation shock, peaking only after two years six months, four years six months, seven years six months at 0.01 percent, 0.04 percent and 0.02 percent respectively, and rising towards the tenth year in SSA. This finding is in line with the study of Olarinde and Abdullahi (2014) which found that crop production responds positively to an increase in its own shock by 73% in the long run. Likewise, CRPROD responds positively, though in a fluctuating trend, to a one percent standard deviation shock in GOEX, with low volatility in both the short and long-run respectively. A one percent shock in GOEX leads to an increase in CRPROD by about 0.02 percent in the third year, experiencing similar peaks after five years six months and seven years six months respectively in SSA. This finding is similar to the studies of Abdkadir and Tunggal (2015), Mehrabian (2015) and Shevchuk and Kopych (2017) which show a significant impact of government expenditure on agricultural productivity in the short run while Tijani et al. (2015) found a significant effect of government expenditure on agricultural growth in the long run. Similarly, CRPROD fluctuates positively in response to one standard deviation shock in TEOT, experiencing low fluctuations in the short-run but returning to equilibrium between the sixth and eighth month, after which it experiences negative shock towards the tenth month. This finding indicates that both government expenditure and terms of trade impact agricultural productivity in the short and long-run in SSA.

In figure 2, a standard deviation shock in CRPROD and TEOT have both short and long-term effects on GOEX in SSA. In the short run, a one percent positive shock in CRPROD increases GOEX by 0.01 percent; but a negative long-run shock up to the eighth year. As with CRPROD, GOEX responds positively to its own shock in both short and long-run, marked with fluctuating periods and peaking at both fourth and seven months. A standard deviation shock in TEOT leads to a negative short-run stability in GOEX up to the third year, then returns to equilibrium between the fifth and seventh year, after which it gradually decreases towards the tenth year in SSA.

Furthermore, there is a positive but fairly stable positive response of TEOT to one percent shock in CRPROD in the short run and long run in SSA. However, a percentage shock in GOEX triggers high but positive fluctuations in TEOT in both short and long run, peaking after five years six months. In response to its own shock, TEOT is positive and gradually decreases until after one and a half years. It then assumes equilibrium until the fourth year, after which it continues to fluctuate both negatively and positively in the long run in SSA. This finding follows Jaroensathapornkul and Tongpan (2007) which concluded that increased government expenditure leads to increased food export/import ratio but decreased trade surplus. It also agrees with Nasrudin et al (2013) that trade openness increases the significant positive effect of fiscal policy on agricultural productivity.

Figure 2: Panel Structural VECM Impulse Response

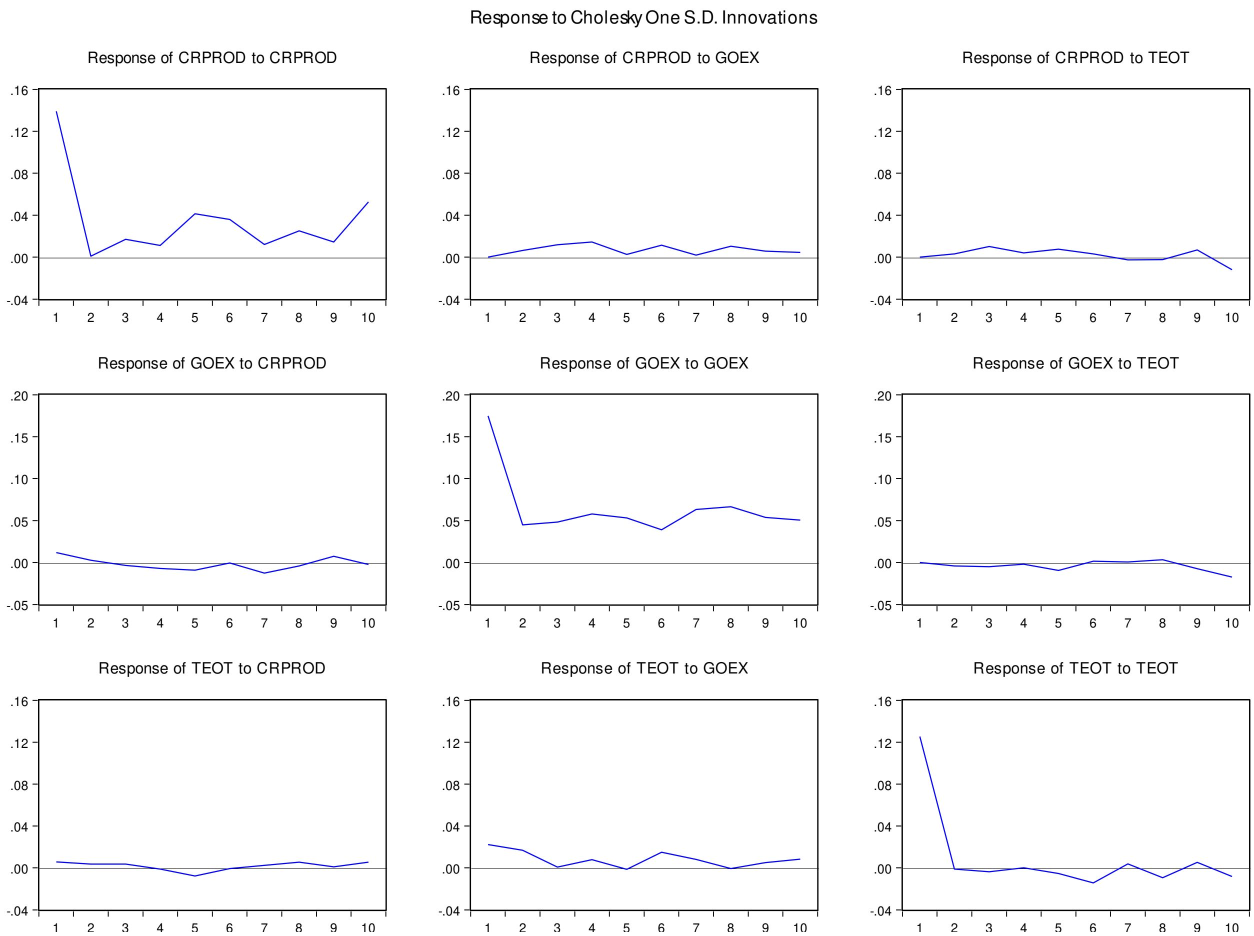

Figure 3 reveals the results of PSVECM variance decomposition. In the first year, GOEX and TEOT do not contribute to the variability in CRPROD in SSA. However, in the third year, both GOEX and TEOT contribute about 82 percent of the fluctuations in CRPROD. This further underscores the high significance of government expenditure and terms of trade in impacting agricultural productivity in the short run in SSA. The impact of GOEX and TEOT steadily increases to about 150 percent of the fluctuations in CRPROD in the tenth year. TEOT contributes more, compared to GOEX, in explaining the fluctuations in CRPROD in both short and long run in SSA. This result also agrees with Odior (2014), Osinowo (2015) and Othuon and Oyugi (2017) which conclude that over 80% of variations in agricultural productivity is explained by changes in fiscal expenditure. In the second panel in figure 3, only CRPROD contributes about 17 percent in explaining the variation in GOEX in the first year. In the third year, both CRPROD and TEOT jointly cause about 86 percent variation in GOEX. This reveals a high level of significance of CRPROD and TEOT in determining GOEX in the short run in SSA. In the tenth year, CRPROD and TEOT significantly explain 190 percent of the variability in GOEX. CRPROD has a higher impact than TEOT in determining fluctuations in GOEX in the short run while TEOT contributes more in explaining variation in GOEX compared to CRPROD in SSA. CRPROD and GOEX jointly contribute about 321 percent and 460 percent significant fluctuations in TEOT in the first and third year respectively. The significance of both CRPROD and GOEX increase to over a huge 1000 percent in explaining the variations in TEOT in the tenth year. GOEX has a higher significance in explaining variability in TEOT compared to CRPROD in both short and long run in SSA. This finding is in line with Fuglie and Rada (2013) which reports that fiscal policy improves agricultural terms of trade in SSA.

Figure 3: Result of Variance Decomposition

Variance Decomposition of CRPROD:

Period	S.E.	CRPROD	GOEX	TEOT
1	0.143246	100.0000	0.000000	0.000000
2	0.143488	99.76795	0.154679	0.077375
3	0.147229	99.17790	0.320618	0.501484
4	0.150975	99.14215	0.374364	0.483485
5	0.160503	98.74969	0.341463	0.908844
6	0.167505	98.80063	0.326093	0.873273
7	0.170708	98.61310	0.424262	0.962638
8	0.175540	98.55784	0.442528	0.999631
9	0.180737	98.50843	0.440104	1.051469
10	0.185997	98.48259	0.447876	1.069531

Variance Decomposition of GOEX:

Period	S.E.	CRPROD	GOEX	TEOT
1	0.178381	0.173497	99.82650	0.000000
2	0.184921	0.290603	99.61710	0.092295
3	0.193729	0.611895	99.13337	0.254736
4	0.211613	0.611416	99.09331	0.295277
5	0.224014	0.600375	98.78580	0.613826
6	0.235360	0.559687	98.40491	1.035402

7	0.247002	0.655597	98.27750	1.066905
8	0.257953	0.657840	98.19236	1.149799
9	0.268142	0.630215	98.12046	1.249327
10	0.278044	0.605751	98.08702	1.307231

Variance Decomposition of TEOT:

Period	S.E.	CRPROD	GOEX	TEOT
1	0.130412	0.167103	3.054098	96.77880
2	0.130882	0.223398	3.636543	96.14006
3	0.131894	0.432818	4.517691	95.04949
4	0.132270	0.431005	5.042678	94.52632
5	0.132754	0.442664	5.715819	93.84152
6	0.134129	0.533024	6.940521	92.52645
7	0.134683	0.561051	7.601032	91.83792
8	0.135254	0.574181	8.269628	91.15619
9	0.135931	0.589697	9.138182	90.27212
10	0.136545	0.627001	9.874871	89.49813

Cholesky Ordering: CRPROD GOEX TEOT

7. SUMMARY AND CONCLUSION

This paper provides new empirical evidence on the existing nexus among fiscal-trade policy and agricultural productivity in 37 selected countries in SSA from 1990 to 2016. Using a PSVECM approach, it models the interrelationships among government expenditure, terms of trade and crop production. The findings underscore the significance and recursive nature of government expenditure and terms of trade in influencing agricultural productivity in the short run in SSA. The analysis further reveals that crop production has a temporary effect on government expenditure while terms of trade responds instantaneously to a transitory shock in government expenditure. In the long run, crop production and government expenditure respond to a shock in terms of trade while government expenditure has a permanent effect on terms of trade in SSA.

The Johansen test reveal the presence of cointegration among the variables. The PSVECM analysis show that government expenditure does not have an immediate effect on terms of trade in the short run. Furthermore, the findings reveal a temporary impact of both government expenditure and terms of trade; and a stable impact of crop production in the long run in SSA. The impulse response analysis shows a mixed result of both short and long run significant relationships among government expenditure, terms of trade and agricultural productivity in SSA. The results show that crop production responds positively to its own standard deviation shock, with high fluctuations both in the short and long-run periods in SSA. A standard deviation shock in crop production and terms of trade have both short and long-term influence on government expenditure, which also responds positively to its own shock in both short and long-run, marked with both short and long-term fluctuating periods. There is also a stable positive response of terms of trade to a unit shock in crop production in the short run and long run. However, a percentage shock in GOEX triggers high but positive fluctuations in TEOT in both short and long run in SSA. In view of this, the study concludes that government expenditure and terms of trade have a short and long run significant impact on crop production in SSA.

The result of the analysis reveals striking significant viewpoints for policy recommendation, particularly in making fiscal budget decisions in SSA. Firstly, in line with the Keynesian approach, policymakers should adopt expansionary fiscal policy to effectively stimulate government expenditure and terms of trade and improve agricultural productivity in both short and long term.

Secondly, policymakers should consider both short and long run agricultural productivity growth strategies since the effects of government expenditure and terms of trade on agricultural productivity are significant in the short and long run.

Thirdly, in line with the 2003 Maputo Declaration on Agriculture and food security and the commitment to the allocation of at least 10% of national budgetary resources to agriculture and rural development policy implementation, governments in SSA must increase budgetary allocation to the agricultural sector, particularly incentives for domestic farmers to increase crop production in order to improve agricultural productivity in the long run. This is crucial because fiscal spending increase favors the agricultural sector, however, past fiscal expenditure on the agricultural sector has been low in most countries in SASA.

Further research on agricultural productivity could be extended to other aspects of agricultural production, other than crop production, as well as to other African regions such as West, East or Southern Africa. Cross-regional comparative research may also be worth conducting to further substantiate if the findings of the subject-relationship in SSA in this study holds in the respective sub-regions suggested as well.

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Appendix

Johansen Fisher Panel Cointegration Test

Series: CRPROD GOEX TEOT
Date: 07/11/18 Time: 14:53
Sample: 1990 2016
Included observations: 999
Trend assumption: Linear deterministic trend (restricted)
Lags interval (in first differences): 1 1

Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	425.9	0.0000	322.6	0.0000
At most 1	174.9	0.0000	168.0	0.0000
At most 2	67.97	0.6754	67.97	0.6754

* Probabilities are computed using asymptotic Chi-square distribution.

Individual cross section results

Cross Section	Trace Test Statistics	Prob.**	Max-Eign Test Statistics	Prob.**
Hypothesis of no cointegration				
1	43.3658	0.0450	24.9636	0.0646
2	66.1329	0.0001	44.4965	0.0001
3	36.5757	0.1861	15.6539	0.5756
4	56.5716	0.0013	31.2717	0.0086
5	49.2777	0.0102	24.5687	0.0725
6	45.2108	0.0289	25.7597	0.0510
7	54.7257	0.0022	27.5413	0.0294
8	51.0974	0.0062	29.8339	0.0140
9	45.9144	0.0243	23.1307	0.1090
10	93.8685	0.0000	66.6442	0.0000
11	42.6384	0.0533	20.3929	0.2214
12	57.5114	0.0010	28.8473	0.0194
13	48.7693	0.0117	23.2167	0.1064
14	61.5157	0.0003	42.8587	0.0001
15	35.5291	0.2239	20.3357	0.2244
16	33.5599	0.3090	22.0271	0.1467
17	62.6763	0.0002	26.0837	0.0462
18	55.9359	0.0016	35.1116	0.0023
19	44.1683	0.0372	26.7488	0.0377
20	42.8290	0.0510	21.9791	0.1486
21	35.6218	0.2204	16.0880	0.5369
22	51.6835	0.0053	28.8049	0.0197
23	56.4322	0.0014	35.4269	0.0020
24	55.5165	0.0018	31.2459	0.0087

25	62.0861	0.0002	37.0963	0.0011
26	34.9282	0.2480	21.8422	0.1540
27	45.2245	0.0288	21.2918	0.1773
28	58.1162	0.0008	29.1337	0.0177
29	52.0012	0.0049	33.0293	0.0047
30	58.7342	0.0007	26.2588	0.0438
31	55.7049	0.0017	26.7748	0.0374
32	55.5207	0.0018	29.7445	0.0144
33	58.5729	0.0007	36.1019	0.0016
34	75.4568	0.0000	39.2953	0.0005
35	57.6633	0.0009	34.6605	0.0026
36	39.5356	0.1046	21.4599	0.1699
37	60.5586	0.0004	40.0998	0.0004
Hypothesis of at most 1 cointegration relationship				
1	18.4022	0.3175	12.7226	0.3509
2	21.6364	0.1540	18.7037	0.0626
3	20.9218	0.1828	15.3908	0.1733
4	25.2999	0.0588	16.8275	0.1133
5	24.7090	0.0693	16.4694	0.1263
6	19.4511	0.2550	14.7953	0.2050
7	27.1843	0.0342	17.4950	0.0922
8	21.2635	0.1686	18.2147	0.0734
9	22.7837	0.1156	20.3078	0.0367
10	27.2244	0.0338	23.1119	0.0137
11	22.2456	0.1325	15.2935	0.1782
12	28.6641	0.0219	20.8505	0.0305
13	25.5526	0.0547	17.4345	0.0940
14	18.6570	0.3015	12.5518	0.3655
15	15.1934	0.5585	10.3180	0.5849
16	11.5328	0.8431	8.3220	0.7918
17	36.5927	0.0016	24.4757	0.0083
18	20.8243	0.1870	17.7501	0.0851
19	17.4195	0.3843	12.6774	0.3547
20	20.8499	0.1859	15.2387	0.1810
21	19.5337	0.2504	12.4984	0.3702
22	22.8785	0.1128	15.4927	0.1683
23	21.0053	0.1793	15.1349	0.1864
24	24.2707	0.0781	16.9634	0.1087
25	24.9898	0.0641	17.1554	0.1025
26	13.0860	0.7315	10.9937	0.5140
27	23.9328	0.0855	17.3117	0.0976
28	28.9825	0.0198	20.7642	0.0314
29	18.9719	0.2824	13.3348	0.3018
30	32.4754	0.0065	21.3872	0.0253

31	28.9301	0.0202	20.2901	0.0369
32	25.7763	0.0514	19.6784	0.0454
33	22.4710	0.1252	16.4566	0.1268
34	36.1615	0.0019	31.1004	0.0006
35	23.0029	0.1092	17.5023	0.0920
36	18.0757	0.3389	13.1907	0.3129
37	20.4587	0.2036	12.5317	0.3673
Hypothesis of at most 2 cointegration relationship				
1	5.6796	0.5020	5.6796	0.5020
2	2.9327	0.8845	2.9327	0.8845
3	5.5310	0.5220	5.5310	0.5220
4	8.4724	0.2155	8.4724	0.2155
5	8.2396	0.2327	8.2396	0.2327
6	4.6558	0.6463	4.6558	0.6463
7	9.6893	0.1420	9.6893	0.1420
8	3.0489	0.8707	3.0489	0.8707
9	2.4758	0.9321	2.4758	0.9321
10	4.1125	0.7258	4.1125	0.7258
11	6.9520	0.3496	6.9520	0.3496
12	7.8136	0.2673	7.8136	0.2673
13	8.1181	0.2422	8.1181	0.2422
14	6.1052	0.4470	6.1052	0.4470
15	4.8753	0.6143	4.8753	0.6143
16	3.2108	0.8506	3.2108	0.8506
17	12.1170	0.0583	12.1170	0.0583
18	3.0741	0.8676	3.0741	0.8676
19	4.7421	0.6337	4.7421	0.6337
20	5.6111	0.5112	5.6111	0.5112
21	7.0353	0.3409	7.0353	0.3409
22	7.3858	0.3060	7.3858	0.3060
23	5.8704	0.4769	5.8704	0.4769
24	7.3073	0.3135	7.3073	0.3135
25	7.8343	0.2655	7.8343	0.2655
26	2.0923	0.9628	2.0923	0.9628
27	6.6211	0.3857	6.6211	0.3857
28	8.2183	0.2344	8.2183	0.2344
29	5.6371	0.5077	5.6371	0.5077
30	11.0882	0.0857	11.0882	0.0857
31	8.6399	0.2037	8.6399	0.2037
32	6.0978	0.4480	6.0978	0.4480
33	6.0145	0.4584	6.0145	0.4584
34	5.0610	0.5876	5.0610	0.5876
35	5.5005	0.5262	5.5005	0.5262
36	4.8850	0.6129	4.8850	0.6129

37	7.9271	0.2577	7.9271	0.2577

**MacKinnon-Haug-Michelis (1999) p-values