Causal Relationship between Economic Growth and Agricultural productivity in Sub Saharan Africa: A Panel Cointegration Approach

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Abstract

The study revisits the causal relationship between agricultural productivity and economic growth in sub-Saharan Africa. The analysis is based on the panel cointegration approach, estimated using the Pooled Mean Group (PMG) estimators. The study employs a cross-country balanced panel data covering 35 countries from 1981 to 2010. Per capita, gross domestic product is an indicator of economic growth, and the total factor productivity (TFP) index is an agricultural productivity indicator used in the study. The empirical results show the variables have a different integration order based on the unit root test, while evidence of a cointegration relationship among the variables exists. The estimated PMG shows that in the long and short-run, agricultural TFP has significant positive and negative effects on economic growth, respectively, in the study. There is no effect of economic growth on agricultural TFP either in the long and short run. While the causality test shows that agricultural TFP Granger causes economic growth in the long and short run, we found no evidence that economic growth Granger causes agricultural TFP in the short run except in the long run. These findings show that greater attention to improving agricultural TFP would increase economic growth in the region.

Keywords: Economic Growth, Agricultural Productivity, Granger Causality, Panel data, Sub Saharan Africa

Introduction

Agriculture remains the central trust of many African countries because it is considered the region's largest economic sector (Gallin 2010). According to Ogundari (2014), agriculture is the principal source of food and livelihood (employment), making it a critical component of programs that seek to reduce poverty and attain food security in the continent. For instance, agriculture accounts for 65% of employment and 20% of Gross Domestic Product-GDP in the region (CTA, 2012; Awokuse and Xie 2015). Interestingly, the agricultural total factor productivity (TFP) growth rate in Africa lags behind the rest of the world. Lusigi and Thirtle (1997) estimated an agricultural TFP growth for Africa at a rate of 1.2 percent per year over 1961-1991. Agricultural production in Africa grew at an average annual rate of 2.6 percent between 1961 and 2008 (Fugli and Rada 2013). Agricultural TFP growth fluctuates rapidly and declines with an average that is roughly 1% per annum between 1961 and 2010 (Rosen et al., 2014). Alene (2010) reported an annual agricultural TFP growth rate of 0.2% based on 1970-2004 data in Africa. Using 1960-2006 data, Yu Nin-Pratt (2011) reported an agricultural yearly TFP growth rate of 1.6% in the region. While this could be considered an improvement on the negative growth rate during the 1960s and the 1970s tagged periods of lost decades (Wiggin, 2014), it is inadequate because the average crop yield in sub-Saharan Africa (SSA) is still about 50 percent less than the average for developing countries (Rosen et al., 2014).

A significant number of African economies have recorded strong Gross Domestic Product (GDP) growth over the years (King and Ramlogan-Dobson, 2015). For instance, the cumulative per capita GDP growth has risen significantly from about 3.5% in the 1980s to 29% in the 2000s in SSA. Also, SSA economies have experienced average GDP growth of about 4.5% and 4.2% in 2013 and 2014 (World Bank, 2015). Given a recent upturn in economic growth, economic and social conditions remain poor and fragile in Africa (Ogundari and Awokuse, 2018). With the widespread evidence that agriculture remains the main engine for economic growth for most African countries in the literature (Gollin, 2010; Barrios et al., 2008), it is vital to understand whether agriculture really matters for Africa's economic growth and vice versa. Because of current efforts to boost Africa's economic growth, this nature's research could help highlight the potential impact of investments in agriculture on the region's economic growth.

The empirical studies on the causal relationship between economic growth and agriculture have yielded mixed and sometimes conflicting evidence with a lack of consensus on the direction of causality (Gollin, 2010). While some literature found increases in agricultural productivity as a prerequisite for economic growth, others disagree and argue for a different path (Gollin, 2010; Getahun et al., 2018; Diao et al., 2010;). It is also possible for agriculture to benefit from wider economic growth processes (Tiffin and Irz, 2006; Gollin, 2010). Thus, arising from the foregoing, how economic growth and agricultural productivity are mutually interacting in the African context is the focus of the present study by addresses the following research questions:

RQ1: What is the short and long-run impact of agricultural total factor productivity on economic growth and vice versa in sub-Saharan Africa?

RQ2: Does agricultural productivity Granger cause economic growth and vice versa in sub-Saharan Africa?

The dual economy model of Lewis (1954) provides a framework for studying the causal relationship between agricultural productivity and economic growth. There are two schools of thought on the causal link between agriculture and economic growth. First, the development of the industrial sector in a country is always accompanied by improvements in productivity and sustainable growth in the agricultural industry. Higher agricultural productivity could be a catalyst for national output via its effect on increasing the rural population's income, thus raising demand for industrial products and providing resources into an industrialized economy (Detheir and Effenbeerger, 2012; Thirstle, 2003). Second, industrial expansion due to economic growth means modern technology and inputs, such as irrigation, become available to boost agricultural productivity (Hwa, 1988). As noted by Los and Bardebroek (2015), general economic growth and increasing options for off-farm income can also positively affect agricultural productivity growth

Many studies have investigated the causal relationship between agriculture and economic growth in Africa (Getahun et al., 2018; Awokuse and Xie 2015, Los and Gardebroek, 2015; Tiffin and Irz, 2006). The present study differs because it considers agricultural total factor productivity (TFP) to measure agricultural productivity. Except for Getahun et al. (2018), many of these studies employed agricultural added value to indicate agricultural productivity. At the same time, Getahun et al. (2018) used a cross country panel covering 1960-2014; the present study used a cross panel covering 1981-2010. Interestingly, agricultural TFP has always been considered a better and accurate measure of production progress or success to informed better policy decisions (Mozundar, 2012).

The empirical results show that in the long and short-run, agricultural TFP has significant positive and negative effects on economic growth, respectively, in the study. There is no effect of economic growth on agricultural TFP either in the long or short run. The causality test shows that agricultural TFP Granger causes economic growth in both the long and short run. We found no evidence that economic growth Granger causes agricultural TFP in the short run except in the long run. The implication of this is that economic growth (GDP) is responsive to agricultural TFP and vice-versa, as causality runs in both directions in the long run in the study. In contrast, the unidirectional causal effect of agricultural TFP on GDP only exists in the short run.

The remaining part of the paper is organized as follows. The following section presents the data and sources used for the analysis. Section 3 contains the analytical framework and empirical models, while Section 4 presents the results and discussion. Concluding remarks are provided in Section 5.

2. Data and Sources

The study employs a balanced panel of 35 countries covering 1981-2010 in sub-Saharan Africa. [1] Data on Gross Domestic Product adjusted by PPP were obtained from the Penn World Table (PWT) database (PWT 2013). The agricultural total factor productivity index were obtained from the United States Department of Agriculture Economic Research Services website (USDA-ERS, 2018). For the empirical analysis, we transformed the variables into their natural logarithm to reduce the disturbing influence of outliers in the data.

However, Table SM1 in the supplementary materials presents the two variables' summary statistics. Figure SM1 in the supplementary materials shows the pairwise scatter plot of GDP and TFP (in logarithm) for the pooled sample and across each country included in the analysis. The univariate linear plots presented in Figure SM2 also in the supplementary materials show a positive linear relationship among the variables similar to the one presented in Figure SM1. However, the

[1] The countries included in the sample are: Angola, Benin, Botswana, Burkina-Faso, Burundi, Cameroon, Chad, Cote'd' Ivoire, Ethiopia, Gabon, Guinea, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

average scatter plot of the univariate relationship among each country's variables provides exciting insights into how each country performs. Figure SM3, also in the supplementary materials, shows the relationship between agricultura; TFP and GDP for each country. A closer look at the figure shows that South Africa, Botswana, and Swaziland, together with Mauritius, are few countries with a large effect of agricultural TFP on GDP and vice versa in the study.

3. Empirical Model

3.1 long-run specification

Consistent with the first research question, the study employs a bivariate long-run specification of the link between per capita gross domestic product (GDP) and agricultural total factor productivity (TFP) based on the specification below.

$$lnGDP_{it} = \alpha + \tau lnTFP_{it} + \epsilon_{it} \qquad \text{1A}$$

$$lnTFP_{it} = \varphi + \gamma lnGDP_{it} + \varepsilon_{it} \qquad \text{1B}$$

$$i = 1, \ldots. N \quad t = 1981 \ldots \ldots T$$

Where, Δ is the differencing operator employ to transform the variables; GDP_{it}denotes the per capita gross domestic product (GDP) for *i* country at t period; TFP_{it} represents agricultural total factor productivity (TFP) index for *i* country at t period; *ln* is logarithm; $\alpha.\ \varphi$, τ , and γ are parameters to be estimated; α and φ represents intercepts; τ and γ represent the long-run effect of lnTFP and lnGDP on $lnGDP_{it}$ and $lnTFP_{it}$ respectively; ϵ_{it} and ε_{it} are the idiosyncratic error for the models.

Equations 1A (GDP-TFP) and 1B (TFP-GDP) defined GDP as a function of agricultural TFP and agricultural TFP as a function of GDP, respectively, which allows us to study the long-run relationship between the pairs of the variables.

3.2. Short-run specification

Consistent with the second research question, the study employs a bivariate short-run specification of the link between per capita gross domestic product (GDP) and agricultural total factor productivity (TFP) based on the specification below.

$$\Delta lnGDP_{it} = \pi + \rho \Delta lnTFP_{it} + \nu_{it} \qquad \text{2A}$$

$$\Delta lnTFP_{it} = \varpi + \zeta \Delta lnGDP_{it} + \mu_{it} \qquad \text{2B}$$

$i = 1, \ldots . N \quad t = 1981 \ldots \ldots T$

Where Δ is the differencing operator employ to transform the variables; GDP and TFP as earlier define; *ln* is logarithm; π, ϖ, ρ, and ζ are parameters to be estimated such that ρ and ζ represent the short-run effect of agricultural TFP on GDP and the short-run effect of GDP on agricultural TFP, respectively; $\nu_{it}$and μ_{it} are the idiosyncratic error for the models.

Equations 2A and 2B defined GDP as a function of agricultural TFP and vice versa, respectively, which allows us to study the short-run dynamic relationship between the series. The lagged differences capture short and long-run dynamics.

3.2. PMG Estimator

Because of the presence of the stationary and non-stationary variables at the level in the data used for the analysis (i.e., a mix of I(0) and I(1) process), the study employs a pooled mean group (PMG) estimators. The methodology is equally useful in controlling for cross-sectional dependence in the cross-sectional time-series panel data. Pesaran et al. (1999) first developed this method for macroeconomic panel data with heterogeneity. The PMG is based on an autoregressive distributive lag (ARDL) model specified below:

$$Y_{it} = \sum_{j=1}^{p} \omega Y_{i,t-j} + \sum_{j=1}^{q} \sigma X_{i,t-j} + \delta_i + \partial_{it} \qquad 3$$

$$i = 1, \ldots . N \quad t = 1981 \ldots \ldots T$$

Where Y_{it} is equivalent to the dependent variables in Equations 1A and 1B [GDP_{it} and TFP_{it}] and X_{it} is equivalent to the explanatory variable in Equations 1A and 1B; ω is the coefficient of lagged values of the dependent variable; σ is the coefficient of variable X_{it} which is equivalent to τ and γ in Equations 1A and 1B respectively; δ_i is the country-specific individual effect; ∂_{it} is the idiosyncratic error for the model.

The traditional Johansen cointegration approach requires I (1) for the cointegrated variable level (Johansen 1988). Simultaneously, any deviation from the long-run equilibrium is a feature of cointegrated variables (Engle and Granger, 1987). In contrast, the PMG estimator specifies in equation 3 based on ARDL requires that all variables have an order of integration between I(0) and I (1) at the levels for cointegration to exist. In recognition of this, equation 3 can be re-parametrized into the error correction model specified below.

$$\Delta Y_{it} = \Theta_i\left(Y_{i,t-1} - \grave{\sigma_i} X_{it}\right) + \sum_{j=1}^{p-1} \beta \Delta Y_{i,t-j} + \sum_{j=1}^{q-1} \grave{\varsigma_i} \Delta X_{i,t-j} + \Xi \frac{-}{Y} + \iota \frac{-}{X} + Year + \Omega_i + \upsilon_{it} \quad 4$$

$$i = 1, \ldots . N \quad t = 1981 \ldots \ldots T$$

Where Δ is the differencing operator; Y_{it} and X_{it} are as defined earlier[2]; Θ_i represents the error correction term (ECT), which captures the speed of adjustment to the long-run equilibrium and is expected to be negative; $\frac{-}{Y}$ and $\frac{-}{X}$ are the average Y_{it} and X_{it} included to control for cross-sectional dependence in the data; Ξ and ι are the parameters to be estimated; Year is the time trend; Ω_i is the country-specific individual effect; υ_{it} is the idiosyncratic error for the model.

Granger causality test minimizes the risk of wrongly identifying the order of integrating the series (Mavrotas and Kelly 2001). Thus, consistent with standard practice in panel cointegration, there are two possible causation sources (see Herzer et al., 2012; Ogundari and Aromolaran, 2017). First, through ECT, and second, through other variables ($X_{i,t}$). Subsequently, three types of causality tests can be performed based on the estimated parameters in Equation 4 outlined below.

Long run Granger causality test

$$H_0: \Theta_i = 0 \ and \ H_1: \Theta_i \neq 0 \quad 5A$$

Short-run Granger causality test

$$H_0: \varsigma_i = 0 \ and \ H_1: \varsigma_1 \neq 0 \quad 5B$$

Strong Causality test

$$H_0: \Theta_i = \varsigma_i = 0 \ and \ H_1: \Theta_i = \varsigma_i \neq 0 \quad 5C$$

Equation 5A shows that long-run causality can be tested by the significance of the coefficient of ECT in Equation 4. The rejection of $H_0: \Theta_i = 0$, implies that X_{it} Granger causes Y_{it} in the long run. Equation 5B shows that short-run causality can be tested the significance of the coefficient of X_{it} in Equation 4. Thus, rejection of $H_0: \varsigma_i = 0$, implies that X_{it} Granger causes Y_{it} in the short run. Finally, Equation 5C shows that the joint significance of the coefficient of ECT and X_{it} implies a test of strong causality. Hence, rejection of $H_0: \Theta_i = \varsigma_i = 0$, implies evidence of

[2] The first difference of the variables taken as an indicator of growth in the study

strong causality exists.[3] While the t-statistics or (p-value) of the ECT coefficient provides evidence of long-run causality, the Wald test of the coefficient of the variables in the short-run equation provides evidence of short-run causality. The Wald test of the coefficient of ECT and the variables in the short-run equation provide evidence of strong causality.

3.3. Panel vector autoregression (VAR) model

The study employs a panel vector autoregressive (VAR) model to investigate how long the impact of a shock in a variable will remain effective in the future and its sign (i.e., positive or negative) on another endogenous variable. As in Holtz-Eakin et al. (1989), a basic *p-lag* (VAR(p)) panel vector autoregressive model of *k* endogenous variables has the matrix of form:

$$Y_{it} = c + \aleph_1 Y_{it-1} + \cdots + \aleph_p Y_{it-p} + \omega_1 X_{it-1} + \cdots + \omega_p X_{it-p} + \xi_i + \chi_{it} \qquad 6$$

Where Y_{it} and X_{it} represent the endogenous variables equivalent to GDP_{it} and TFP_{it}, respectively; $\aleph_p$, ω_p, and c paramterd to be estimated; ξ_i denoted country-specific effect; χ_i is the idiosyncratic error for the model.

4. Results and discussions

4.1 Cross-sectional independence

The macroeconomic panel data are most likely to exhibit substantial cross-sectional dependence in the errors, which bias the results' efficiency. In recognition of this, Table 1 presents the result of cross-sectional independence developed by De Hoyos and Sarafidis (2006) for Peseran's (2004) and Friedman's (1936) test statistics. Based on the two statistics, we reject the null hypothesis of cross-sectional independence, thus confirming cross-sectional dependence in the data.

----- Table 1 Here ------

4.2. Panel Unit root test

With clear evidence of cross-sectional dependency in Table 1, we conduct panel unit root tests that accommodate the data's cross-sectional dependence. Hence, Table 2 presents the Pesaran panel unit root test in the presence of cross-section dependence using the cross-sectional augmented

[3] Strong causality do not distinguish between short run and long run causality

Dickey-Fuller regression (CADF) model following Peseran (2003) and cross-sectional augmented Im-Pesaran-Shin (CIPS) following Pesaran (2007).

The results show that variables have a mixture of non-stationary (I(1)) and stationary (I(0)), which suggests that the variables have an order of integration between I(0) and I (1) at the levels. However, the variables are stationary (I(0)) at the first difference, judging by the p-values reported in the table.

----- Table 2 Here ------

4.3. Panel cointegration Test

To investigate whether there exist long-run equilibrium relationships among these variables, we employ a cointegration test that accommodates cross-section dependence in the data. Given this, the study uses Westerlund's (2006) second generation panel cointegration test. The results are presented in Table 3 and show evidence of a long-run cointegration relationship, especially with the trend in both specifications. For example, we find a long-run equilibrium relationship with GDP as the dependent variable and agricultural TFP as the independent variable with and without a time trend. A cointegration relationship was also found with agricultural TFP as the dependent variable and GDP as an independent variable with a time trend.

----- Table 3 Here ------

4.4. Short and Long-Run Effects of Agricultural TFP and Economic Growth

Table 4 presents the results of the long and Short-run effects of agricultural TFP on economic growth and vice versa based on the pooled mean group (PMG) and dynamic fixed effect (DFE) estimators proposed by Pesaran et al. (1999). Table 4A shows that the long-run effect of agricultural TFP on economic Growth (GDP) is positive and significant. In contrast, GDP's long-run effect on agricultural TFP growth is insignificant in Table 4B. The short-run effect of agricultural TFP on economic growth is negative and significant in Table 4A. Likewise, the short-run effect of GDP on agricultural TFP growth is not significantly different from zero.

These findings indicate that agriculture contributes significantly to economic development in SSA, with a lack of evidence that supports the contribution of economic growth to the agricultural sector in the region. As noted that by Timmer (1995), agriculture's contribution to economic growth comes via better caloric nutrient intake by the poor, food availability, food price stability, increasing income for the rural population, and poverty reduction.

4.5. Causality between Economic growth and Agricultural TFP

The study of the long and short-run relationship between economic variables is insufficient to establish a causal effect for policy inferences. In recognition of this, we test causality among the variables.

Before we discuss the causality test, it is vital to discuss the results of the estimated error correction terms (ECT). The coefficient of estimated error correction terms (ECT) in Tables 4A and 4B has the appropriate negative sign and is significantly different from zero. This indicates a variable adjustment mechanism in the long run in both specifications. In other words, GDP tends to converge to its long-run equilibrium path in response to changes in agricultural TFP and vice versa in the long run, given the significant and negative sign of ECT's coefficient. However, the speed of adjustment to long-run equilibrium in Tables 4A and 4B is about 8% and 18%, respectively, for the PMG estimator. The implication of this is that 8% and 18% of the previous period's imbalance reunited into long-run equilibrium in the current period in Tables 4A and 4 B, respectively, which is slow and not particularly strong. Simultaneously, the speed of adjustment in Table 4A and 4B is about 8% and 11%, respectively, for the DFG estimator, which is also slow. The evidence of the slow speed of adjustment could be an indication that the agriculture and economic sector proceed relatively slowly in the region

Hence, the Granger causality test results are presented in the lower panel of Table 4. We investigate the short run, long-run, and strong causality. The results show that agricultural TFP Granger causes economic growth in both models' short and long-run estimates. We also find evidence of a combined effect of the long and short-run causality of agricultural TFP on economic growth in the study (i.e., strong causality). The implication of this is that (i) economic growth tends to converge to its long-run equilibrium path in response to changes in agricultural TFP, and (ii) it also shows that agricultural TFP indeed Granger causes economic growth in the long and short-run. Table 4B provides mixed results. While there is evidence that GDP Granger causes agricultural TFP growth in the long run, we do not find such evidence in the short run. We find evidence of strong Granger causality, a combined-long and short-run causal effect of GDP on agricultural TFP growth in the study. These results suggest evidence of a bidirectional causal relationship between agricultural TFP and GDP in the long run. In other words, economic growth (GDP) is responsive to agricultural TFP and vice-versa and implies that causality runs in both directions in the long run. In contrast, evidence of unidirectional causation from agricultural TFP to GDP in the short run exists in the study. Finally, the strong causality test shows that Granger causality runs in both directions.

Most empirical literature supports unidirectional causality from agriculture to economic growth in Africa (Getahun et al., 2018; Awokuse and Xie 2015, Los and Gardebroek, 2015), aligning with the result of the short-run causality in the present finding. Tiffin and Irz (2006) found evidence supporting bidirectional causality between agriculture and economic growth for developing countries, similar to the current finding's long-run causality. The implication of this is that the aggregate economy's growth could catalyze change in SSA's agricultural sector and vice versa in the long run.

4.6. Impulse response function

The Granger causality test only indicates which models' variables significantly impact each system's future values. This could not show how long these impacts will remain effective in the future and its sign (i.e., positive or negative). The impulse response function (IRF) provides more insight into shocks' effect (i.e., response) to macroeconomic variables. According to Kandil et al. (2015), the IRF describes one variable's reaction to the innovation in another variable in the system while holding all other shocks equal to zero. IRF is constructed from the estimated VAR coefficients. Hence, we estimate an IRF using the panel vector autoregressive (PVAR) model based on the study variables' first differences. The full PVAR model is not reported for brevity but could be requested from the author.

The result presented in Figure 4 traces the shocks' impact over 10 years. Although shocks to a variable affect itself and other variables, we only present the shock to other dynamic system variables. The IRF shows a positive response of agricultural TFP to shocks in GDP (Left-hand Figure) and a positive GDP response to shocks in agricultural TFP (Righ hand figure) and is transitory starting in the second period.[4] Precisely, a shock to GDP exerts a positive effect and reached a maximum length after two periods on agricultural TFP and vice versa in the study. Also, a shock in GDP exerts a negative and zero effect on agricultural TFP and vice versa after the 2nd and 4th periods, respectively. Both models show a similar response to macroeconomic shocks. For instance, the shape of IRFshows that GDP has a more significant positive influence on agricultural TFP in the short term (i.e., two periods) and vice versa.

Given that agriculture accounts for the lion's share of overall gross domestic product (GDP) in Africa, an important policy implication from these findings highlights the potential impact of investments in agriculture on the region's economic growth in both the long and short run. In other words, efforts to promote higher agricultural productivity mean the increasing income of the rural population and food security, thus raising demand for industrial or domestic products in the region, as noted by Detheir and Effenbeerger (2012). The finding also supports the literature argument that investment in agriculture is a critical component of programs that seek to reduce poverty and attain food security in the continent in both the short and long run, as noted by Ogundari (2014).

----- Tables 4A & 4B Here ------

----- Figure 1 Here ------

5. Concluding Remarks

The paper revisits the causal relationship between economic growth and agriculture in SSA. The study is based on cross-country balanced panel data covering 35 countries from 1981 to 2010. We employ a panel Cointegration approach for the empirical analysis, estimated using the Pooled Mean Group (PMG) estimators. The results show that in the long and short-run, agricultural TFP has significant positive and negative effects on economic growth, respectively, in the study. There is no effect of economic growth on agricultural TFP either in the long and short run. We also find that GDP tends to converge to its long-run equilibrium path in response to changes in agricultural

[4] Macroeconomic shocks affecting agriculture could be technology adoption, change in input prices, government policies that affect exchange rates, inflation, etc. Macroeconomic shocks affecting economic growth could be deregulation, exchange rate policies, inflation, taxation, etc.

TFP and vice versa in the long run, given the significant and negative sign of the error correction term (ECT)'s coefficient in the study.

Granger causality tests show that agricultural TFP Granger causes economic growth in the long and short run. We find no evidence that economic growth Granger causes agricultural TFP in the short run except in the long run. The implication of this is that a bidirectional causal relationship between Agricultural TFP and economic growth exists in the long run. In contrast, the result shows evidence of unidirectional causation from Agricultural TFP to economic growth in the short run.

We also estimate an impose response function (IRF) using the panel vector autoregressive (PVAR) model based on the study variables' first differences. The result shows a positive response of agricultural TFP to shocks in GDP and a positive GDP response to shocks in agricultural TFP. It is transitory, starting in the second period. In other words, GDP has a significant positive influence on agricultural TFP in the short term (i.e., two periods) and vice versa. This finding is consistent with the evidence of bidirectional causality between economic growth and agricultural TFP in the long run obtained in the study.

These findings highlight the potential impact of investments in agriculture on the region's economic growth in both the long and short-run. For instance, policies aimed at increasing agricultural TFP could catalyze change in economic growth in the region. Such policies could include intensification of agricultural technology adoption, improved extension services, and an efficient credit market.

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Table 1: Cross-sectional independence

Equation	Test	Statistics	P-value
lnGDP=f(lnTFP	Pesaran (2004)	11.287***	0.0000
lnTFP=f(lnGDP)		8.833***	0.0000
lnGDP=f(lnTFP	Friedman (1937)	88.085***	0.0000
lnTFP=f(lnGDP)		96.297***	0.0000

Ho: cross-sectional independence

Table 2: Pesaran Panel Unit Root Test in the Presence of Cross-section Dependence

Test	Variables	Unit	Intercept without a trend (Zt-bar)	Intercept with a trend (Zt-bar)
CADF (Peseran 2003)	lnGDP	Level	-0.288 [0.387]	-3.234*** [0.001]
	lnTFP	Level	-1.955** [0.025]	-0.869*** [0.013]
	lnGDP	First Difference	-19.466***[0.000]	-11.994***[0.000]
	lnTFP	First Difference	-22.912***[0.000]	-9.538*** [0.000]
CIPS (Peseran 2007)	lnGDP	Level	-1.888 [0.236]	-4.860*** [0.000]
	lnTFP	Level	-2.121* [0.092]	-5.447*** [0.000]
	lnGDP	First Difference	-4.860*** [0.000]	-5.085*** [0.000]
	lnTFP	First Difference	-5.447*** [0.000]	-5.565*** [0.000]

Ho: Series have unit root (non-stationary)

Table 3: Panel cointegration test

Test	Statistic	Equation (without trend)		Equation (with trend)	
		lnGDP=f(lnTFP)	TFP=f(TFP)	lnGDP=f(lnTFP)	lnTFP=f(lnTFP)
Westerlund (2006)	Variance ratio	1.5357*** [0.0503]	-0.5646 [0.2862]	1.4536*** [0.0430]	-2.0139**[0.0220]

Ho: No cointegration

Table 4A: Long and Short-run effect of Agricultural TFP on Economic Growth in SSA

Equation:	Variables	Dependent variable: $\Delta lnGDP_t$	
		PMG	DFG
Long-run	$lnTFP_t$	1.4541*** [0.2183]	0.8484*** [0.3756]
	Time trend	0.0249*** [0.0025]	0.0169*** [0.0047]
Short-run	$\Delta lnTFP_t$	-0.1569*** [0.0481]	-0.0918*** [0.0347]
	ECT_t	-0.0793*** [0.0165]	-0.0859*** [0.0182]
	Constant	-3.9021*** [0.8154]	-2.6194*** [0.7717]
Causality tests	Long run causality (($\Delta lnTFP_t \rightarrow \Delta lnGDP_t$)#	0.000	0.001
	Short run causality ($\Delta lnTFP_t \rightarrow \Delta lnGDP_t$)#	0.000	0.000
	Strong Causality (Joint Short &long run $\rightarrow \Delta lnGDP_t$)#	0.000	0.001

Standard errors are shown in parentheses.; ⁎ p b 0.10.; ⁎⁎ p b 0.05.;⁎⁎⁎ p b 0.01: # P-values provided; Note Average GDP and Agricultural TFP are included in the short run but not reported

Table 4B: Long and Short-run effect of Economic Growth (GDP) on Agricultural TFP in SSA

Equation	Variables	Dependent variable: $\Delta lnTFP_t$	
		PMG	DFG
Long-run	$lnGDP_t$	-0.1826 [0.5263]	0.0266 [0.1044]
	Time trend	0.0048*** [0.0007]	0.0083*** [0.0026]
Short-run	$\Delta lnGDP_t$	-0.0529 [0.0366]	-0.0132 [0.0180]
	ECT_t	-0.1877*** [0.0400]	-0.1181*** [0.0357]
	Constant	-0.7017*** [0.1553]	-1.4395*** [0.5681]
Causality tests	Long run causality ($\Delta lnGDP_t \rightarrow \Delta lnTFP_t$)#	0.000	0.005
	Short run causality ($\Delta lnGDP_t \rightarrow \Delta lnTFP_t$)#	0.148	0.464
	Strong Causality (Joint Short &long run$\rightarrow \Delta lnTFP_t$)#	0.000	0.001

Standard errors are shown in parentheses.; ⁎ p b 0.10.; ⁎⁎ p b 0.05.;⁎⁎⁎ p b 0.01; # P-values provided; Note Average GDP and Agricultural TFP are included in the short run but not reported

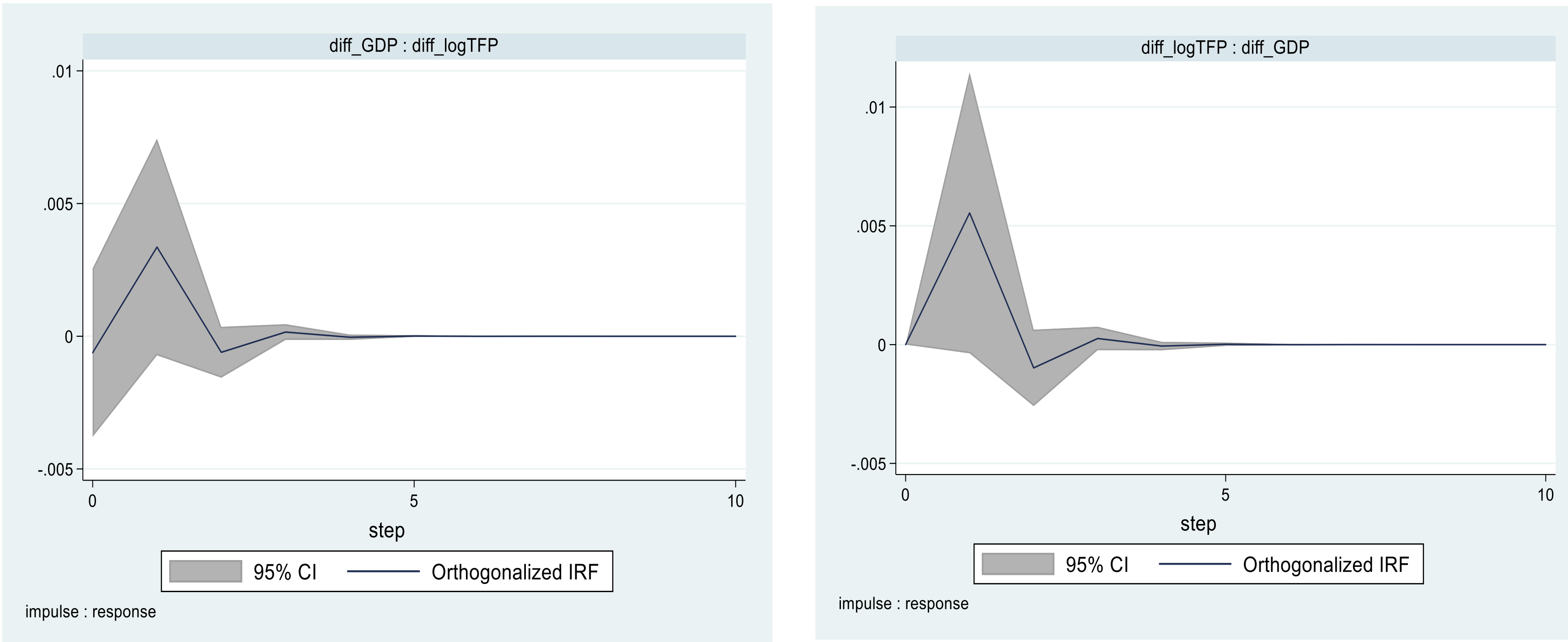

Figure 1: Impulse response of function of Agricultural TFP and GDP