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Drivers of Agricultural Productivity in Agriculture-Based Economy

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ABSTRACT
Stagnation in agricultural productivity, especially in an economy with fast and persistently growing population, would compromise food security. This study examined the factors influencing agricultural productivity in an agriculture-based economy. The study used a 35-year period (1980 – 2014) panel data focusing on Agricultural Productivity (AP), Real Gross Domestic Product (GDP), Government Agricultural Expenditure (EXP), Agricultural Trade Barrier (ATB), Consumer Price Index (CPI), Farm Machinery (MACH), Fertilizer Consumption (FERT), Human Capital (HCAP) and Irrigation (IRRG). Data were analyzed using Impulse Response Function (IRF) and Panel Least Squares (PLS) regression technique. The IRF revealed that there was a positive and stable response of GDP to shocks in AP in agriculture-based economy. Panel Least Squares revealed that consumer price index ($p<0.01$), irrigation ($p<0.01$) and machinery ($p<0.01$) increased AP in agriculture-based economy. However, FERT decreased ($p<0.01$) AP in agriculture-based economy. The study concluded that AP will grow in agriculture-based economy with an expansion in irrigation application, farm machinery and appropriate use of fertilizer. Therefore, improved irrigation infrastructure and farm machinery that will enhance smallholder farmer's capacity for all-season cropping and appropriate application of fertilizer should be encouraged for increased agricultural productivity in agriculture-based economy.

Keywords: Africa, agricultural growth determinants, food security, impulse response function, total factor productivity.
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1 INTRODUCTION

Improving agricultural productivity has been the world's primary means of assuring that the needs of a growing population do not outstrip the ability to supply food. Productivity measures the efficiency with which inputs are transformed into outputs in a given economy (Li & Prescott, 2009; Shittu & Odine, 2014).

Global Harvest Initiative (GHI) revealed that global agricultural productivity growth is not accelerating fast enough to sustainably feed the world because of stagnant or slowing agricultural productivity in many countries (GHI, 2015). This is particularly the case in many developing economies that relied largely on land expansion to drive agricultural growth. Given that land is a scarce resource, expansion of more cultivated area is not possible in many developing countries (Mozumdar, 2012). Therefore, factors other than land should be employed to solve the problem of low agricultural productivity in the nexus of an increasing population that can impede food security.

Global agricultural productivity has attracted the interest of economists for a long time (Wik et al., 2008; GHI,2015). As agriculture develops, it releases resources to other sectors of the economy, which has been the base of successful industrialization in most developed economies. Thus, agricultural development becomes an important pre-condition of structural transformation towards industrial development, as it precedes and promotes industrialization (Eicher & Witt, 1964; Oluwasanmi, 1966; Jones & Woolf, 1969; Ludena, 2010). Productivity growth in agriculture has been a subject matter for an intensive research over the last five decades (Shittu & Odine, 2014; GHI's 2015). It is considered essential for agricultural sector to grow at a sufficiently rapid rate to meet the demands for food and raw materials arising out of steady population growth (Coelli & Rao, 2003; GHI, 2015).

Within the context of growth in food and agriculture, emphasis is placed on productivity because expansion of arable land is very limited in most countries due to physical lack of suitable land and/or because of environmental priorities (Zepeda, 2001). In addition, the difference between actual and technically feasible yields for most crops implies great potential for increasing food and agricultural production through improvement in productivity.

GHI (2015) calculated that global agricultural productivity must grow by an average rate of at least 1.75% annually in order to double agricultural output through productivity gains by 2050. While output of food, feed, fiber and fuel will most likely continue to rise in coming decades to keep up with growing global demand, experts are concerned that this production will come at the expense of the environment and natural resource base. Proven practices and technologies, if adopted more widely, can be part of a solution to accelerate global agricultural productivity in sustainable ways that actually reduce agriculture's overall impact on soil, forests and water resources (GHI, 2015).

WDR (2008) classifies countries according to the contribution of agriculture to economic growth and the share of the poor in the rural sector. In "agriculture-based" countries, agriculture contributes 20% or more to Gross Domestic Product (GDP) and more than half of the poor live in rural areas. In "transforming" economies, agriculture contributes less than 20% but poverty is still mostly rural, while in "urbanized" economies, agriculture contributes less than 7% to GDP and poverty is mostly urban.

It is increasingly obvious that improvement in agricultural productivity and growth can forestall rural poverty, but evidence-based macroeconomic policies and instruments are prerequisites. The agricultural policies and programmes over the years for many developing countries have been inconsistent, poorly implemented and mostly emerged as ad hoc attempts. A paradigm shifts towards sound evidence-based policies anchored on sound macroeconomic policies is needed to promote a more equitable and environmentally sustainable agricultural productivity.

In the light of the central role that agriculture plays in the development strategy of most developing countries, this work examines the drivers of agricultural productivity in agriculture-based economy. Specifically, the objectives of this study are to:

i. evaluate the economy (GDP) reaction to structural shocks in agricultural productivity in agriculture-based economy between 1980 and 2014; and

ii. determine the drivers of agricultural productivity in agriculture-based economy between 1980 and 2014.

The remainder of the paper is divided into four sections. Section two focuses on theoretical and empirical reviews. Section three spells out the methodology, section four presents the results and discussions while section five concludes the report.

2 LITERATURE REVIEW

Increasing productivity of agriculture by promoting technical innovation and ensuring optimum use of factors of production is one of the objectives of agricultural policy. A sustainable growth of agricultural sectors and their productivity is an important goal of governments worldwide since agriculture represents an important sector of the economy and provides inputs for other industries (Machek & Spicka, 2014).

Fulginiti et al. (1998) examined changes in agricultural productivity in 18 developing countries over the period of 1961 to1985. The study used a nonparametric, output based Malmquist index and a parametric variable coefficient Cobb-Douglas production function to examine whether declining agricultural productivity in less developed countries was due to use of inputs. Econometric analysis showed that most output growth was as a result of commercial inputs like machinery and fertilizers.

The study of Brownson et al. (2012) established the empirical relationship between agricultural productivity and some key macroeconomic variables in Nigeria. The empirical results revealed that in the short- and long-run periods, the coefficients of real total exports, external reserves, inflation rate and external debt have significant negative relationship with the agricultural productivity. The findings call for appropriate short and long-term economic policy packages that should stimulate investment opportunities in the agricultural sector so as to increase agricultural component in the country's total export.

Shittu and Odine (2014) examined the role of international trade and economic integration as well as quality of governance and public/private investment in explaining the wide differences in agricultural productivity growth performance among countries in Sub-Saharan Africa (SSA) between 1990 and 2010. The study was based on a panel data of 42 countries in SSA over the period 1990 – 2010. The study revealed the need for substantial capital deepening and increase in public expenditure as key measures needed to significantly raise agricultural productivity in SSA.

Nkamleu (2007) investigated the sources and determinants of agricultural growth. The study generally examined agricultural output and productivity growth in relation to some determinants in different countries. The analysis employs the broader framework of empirical growth literature and recent developments in Total Factor Productivity (TFP) measurement to search for fundamental determinants of growth in African agriculture. One main contribution of this finding is the quantification of the contribution of the productivity growth and the contribution of different inputs such as land, labour, tractor and fertilizer to agricultural growth. Growth accounting highlights the fact that factor accumulation rather than TFP accounts for a large share of agricultural output growth and that fertilizer has been the most statistically important physical input contributor to agricultural growth.

Chavas (2001) analyzed international agricultural productivity using nonparametric methods to estimate productivity indices. The analysis used FAO annual data on agricultural inputs and outputs for twelve developing countries between 1960 and 1994. Technical efficiency indices for time series analysis results suggested that in general, the technology of the early 1990s was similar to the one in the early 1960s. This showed that the improvement in agricultural production was not because of technology but because of other inputs such as fertilizer and pesticides. The general empirical results indicated only weak evidence of agricultural technical change and productivity growth both over time and across countries. There was much evidence of strong productivity growth in agriculture over the last few decades corresponding to changes in inputs.

Thirtle (2003) reported that the productivity growth arising from research-led technological change in agriculture has been generating sufficiently high rates of return in Africa and Asia that has been reducing the number of poor people by about 27 million per annum in these regions. The main effect of agricultural productivity growth in SSA was shown to be significant increases in per capita incomes, with income increases finally having significant poverty-reducing effects (Alene & Coulibaly, 2009). Irz et al. (2001) noted that "it is unlikely that there are many other development interventions capable of reducing the numbers in poverty so effectively" as increased agricultural productivity.

Saungweme and Matandare (2014) in their paper looked at the effects of central government's expenditure towards the agricultural sector and the subsequent effect of this on economic activities. Zimbabwe, like many other world countries, has supported the agricultural sector given its positive forward and backward linkages with other economic sectors. The results of this study indicate that increased agriculture expenditure before 2000 has boosted production in the sector and strengthened forward and backward economic linkages. However, the land reform programme of 2000 and subsequent reduction in sound government support to the sector contributed immensely to the economic crises in Zimbabwe. The study recommends effective government support to the agricultural sector through credible productive policies and financial and non-financial resources.

Cao and Birchenall (2013) examined the role of agricultural productivity as a determinant of China's post-reform economic growth and sectoral reallocation. Using microeconomic farm-level data, and treating labour as a highly differentiated input, the study revealed that the labour input in agriculture decreased by 5% annually and agricultural TFP grew by 6.5%. Using a calibrated two-sector general equilibrium model, the study showed that agricultural TFP growth contributed to aggregate and sectoral economic growth and TFP growth also reduced farm labour and thus influences economic growth primarily by reallocating workers to the non-agricultural sector, where rapid physical and human capital accumulation are currently taking place.

Table 1 showed Agriculture, value added (% of GDP) of thirty-five (35) cross-sectional units (countries) that were selected from agriculture-based countries for this study over the last decade.

3 RESEARCH METHODOLOGY

This study employed panel data covering thirty-five (35) year period of 1980 to 2014. The data were sourced from World Bank's World Development Indicators (WDI), Penn World Table, Food and Agriculture Organization (FAOSTAT), United States Department of Agriculture (USDA) and Statistics on Public Expenditure for Economic Development (SPEED). The data focused on Agricultural Productivity (AP), Government Agricultural Expenditure (EXP), Agricultural Trade

Barrier (ATB), Consumer Price Index (CPI), Farm Machinery (MACH), Fertilizer Consumption (FERT), Human Capital (HCAP), and Irrigation (IRRG).

Table 1: Agriculture, value added (% of GDP) of Selected Countries

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Afghanistan	31.75	29.25	30.62	25.39	30.21	27.09	24.51	24.60	23.89	23.46
Albania	21.23	20.22	19.87	19.42	19.41	20.66	20.96	21.66	22.50	22.92
Benin	27.53	28.26	27.62	27.18	26.90	25.83	25.64	25.12	24.12	24.29
Burkina Faso	39.03	36.72	32.75	40.24	35.57	35.62	33.85	35.06	35.61	35.67
Burundi	44.50	44.34	37.34	40.59	40.53	40.45	40.35	40.58	39.83	39.26
Cambodia	32.40	31.65	31.88	34.85	35.65	36.02	36.68	35.60	33.51	30.51
Cameroon	20.59	21.02	22.90	23.43	23.48	23.39	23.57	23.18	22.89	22.16
CAR	54.94	55.18	54.28	55.72	54.63	54.20	54.50	53.94	46.43	42.16
Chad	54.84	56.72	56.00	55.92	47.86	53.37	53.11	55.09	51.92	52.62
Congo	22.38	22.34	22.85	24.17	25.16	23.34	24.04	23.12	22.17	21.15
Ethiopia	44.70	45.88	45.46	48.43	48.64	44.74	44.67	47.98	44.90	41.92
Gambia	29.67	24.27	22.95	27.76	29.30	31.73	24.61	24.54	23.64	20.34
Ghana	40.94	31.12	29.74	31.72	32.91	30.83	26.02	23.60	23.15	22.40
Guinea	24.16	23.84	25.35	24.95	25.86	22.04	22.06	20.54	20.24	20.11
Kenya	27.20	23.16	23.27	24.92	26.14	27.83	29.27	29.09	29.48	30.25
Lao PDR	36.18	35.26	36.06	34.87	35.04	31.45	29.59	28.07	26.39	27.61
Liberia	66.03	63.82	65.60	67.26	58.04	44.80	44.30	38.80	37.23	35.77
Madagascar	28.29	27.48	25.69	24.84	29.14	28.06	28.37	28.20	26.42	26.45
Malawi	37.11	34.41	30.56	32.34	32.81	31.92	31.25	30.58	30.77	30.81
Mali	36.06	33.02	34.43	36.07	35.14	36.20	37.59	41.34	39.84	40.33
Micronesia	24.42	24.45	27.04	28.01	26.77	26.54	28.19	30.58	28.81	26.96
Mozambique	25.62	26.68	26.68	29.07	30.07	29.52	28.56	27.65	26.57	25.05
Myanmar	46.69	43.92	43.32	40.28	38.11	36.85	32.50	30.59	29.53	27.83
Nepal	36.35	34.64	33.56	32.73	34.03	36.53	38.30	36.49	35.05	33.81
Niger	42.88	40.97	43.21	39.21	40.9	38.25	38.08	38.44	39.27	39.86
Nigeria	32.76	32.00	32.71	32.85	37.05	23.89	22.29	22.05	21.00	20.24
Pakistan	21.47	23.01	23.06	23.11	23.91	24.29	26.02	24.55	24.81	24.87
Rwanda	40.90	41.80	37.35	34.96	36.13	34.75	34.67	35.33	35.11	35.03
Sierra Leone	52.46	52.89	54.76	56.35	57.32	55.15	56.72	52.52	49.72	53.96
Sudan	31.53	29.81	26.68	25.80	26.26	24.61	25.44	40.63	41.73	39.90
Tajikistan	23.95	24.20	22.22	22.74	20.86	22.07	27.21	26.60	27.41	27.25
Tanzania	30.46	30.97	28.78	30.83	32.37	31.96	31.29	33.17	33.29	31.01
Togo	39.41	35.88	35.82	40.71	32.91	31.03	30.76	42.60	39.72	41.97
Tuvalu	22.59	24.94	25.43	24.23	26.23	28.70	27.59	22.01	22.16	22.36
Uganda	26.70	25.59	23.63	22.74	28.23	28.26	26.88	27.96	27.07	26.67

Sources: World Bank (2016). CAR: Central African Republic

For the purpose of this research work, the countries with regular and complete data required for this study were selected from agriculture-based economies. Thus, thirty-five (35) cross-sectional units (countries) were selected from agriculture-based countries with 35 time periods. In all, there are 1225 observations. Table 2 shows the description, sources and unit of measurement of the data used.

Table 2: Data description, unit, and sources

Variable Code	**Variable Name**	**Functional description of the variables**	**Unit of Measure ment**	**Sources**
AP_t	Agricultural Productivity	This is proxy by Agricultural Total Factor Productivity indexes using FAO Gross Agricultural Output & weighted-average input	Index Base Year = 2014	USDA, 2017 Database
EXP_t	Government Agricultural Expenditure	Outflow of resources from government to agricultural sector of the economy	Constant 2005 US dollar (Millions)	SPEED, 2015
ATB_t	Agricultural Trade Barrier	Agricultural trade barrier is proxied by Net barter terms of trade index. Calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year.	Index Base Year = 2000	World Bank, 2016 Database , (WDI)
CPI_t	Consumer Price Index	Change in purchasing power of a currency and the rate of inflation. CPI measures effect of inflation on purchasing power.	Index Base Year = 2000	USDA, 2017 Database
$HCAP_t$	Human Capital	Human capital index, based on years of schooling and returns to education; (Human capital in Penn World Table, PWT9). Education, skill and knowledge enhance ability of labor to use new technologies more productively.	Index	2015 Penn World Table, version 9.0
$MACH_t$	Farm Machinery	The total stock of farm machinery in 40 CV Tractor-Equivalents in use (4w, 2w tractors, harvester-threshers, milking machines, aggregated by CV/ machine weights)	Number	USDA, 2017. Database
$FERT_t$	Fertilizer Consumption	Metric tonnes of fertilizer consumption measured in "N-fertilizer equivalents," where tonnes of fertilizer types are aggregated using weights based on their relative prices.	Metric tons	USDA, 2017. Database
$FERT_t$	Fertilizer Consumption	Metric tonnes of fertilizer consumption measured in "N-fertilizer equivalents," where tonnes of fertilizer types are aggregated using weights based on their relative prices.	Metric tons	USDA, 2017. Database

$IRRG_t$	Irrigation	Area equipped for irrigation. Irrigation is the supply of water to crops to help growth.	Hectares	USDA, 2017. Database
GDP_t	Real Gross Domestic Product	Real Gross Domestic Product is an inflation adjusted measure that reflects the value of all goods and services produced by an economy in a given year, expressed in base-year prices.	Constant 2010 US dollar (Millions)	World Bank, 2016 Database (WDI)

The first objective (evaluate the GDP reaction to structural shocks in agricultural productivity in agriculture-based economy between 1980 and 2014) was analyzed by Impulse Response Function (IRF) as used by Ben-Kaabia *et al*., 2002; Brownson *et al*., 2012 and Onanuga and Shittu, 2010. While the second objective (determine the drivers of agricultural productivity in agriculture-based economy) was analyzed using panel least square (fixed and random effects) as used by Atif *et al.* (2011), Greene (2001) and Gujarati (2003).

3.1 Impulse Response Function (IRF)

IRF shows the effect of shocks on the adjustment path of the variables. It describes the evolution of the variables of interest along a specified time horizon after a shock in a given moment (Hamilton, 1994; Onanuga & Shittu, 2010; Muftaudeen & Hussainatu, 2014). IRFs show the reactions of the variables to a unitary shock of one standard deviation (Schalck, 2007). IRFs are typically illustrated by graphs that provide a visual representation of responses, it also allows us to examine dynamic interactions among variables and the feedback effects on each other (Davtyan, 2014).

IRFs are intuitive tools to analyze interactions among variables in Vector Autoregressive (VAR) models. IRFs produce a time path of dependent variables attributed to shock from the explanatory variable, thus the model is specified as:

$$AP = \alpha_1 + \alpha_2 GDP_{t-1} + \alpha_3 AP_{t-1} + \varepsilon_1 \quad \text{(i)}$$
$$GDP = \alpha_4 + \alpha_5 AP_{t-1} + \alpha_6 GDP_{t-1} + \varepsilon_2 \quad \text{(ii)}$$

Where:
AP_t = Agricultural Productivity
GDP_t = Real GDP
$\varepsilon_1 and\ \varepsilon_2$ = residual of agricultural productivity and real GDP.

A positive shock is given to the residuals (that is $\varepsilon_1 and\ \varepsilon_2$) of the above VAR model to see the response of the variable to each other. The structural shocks, which are considered as one-standard deviation to the variables, are recovered and they get their natural economic meaning. The IRF was identified by the Cholesky decomposition, which requires imposing the ordering of the variables that describe the contemporaneous relations among them. Thus, we need to specify the ordering of the variables that have economic reasoning behind it.

To see this and keep things simple, we can express equation (i) and (ii) in its Vector Moving Average (VMA) representation by using recursive substitution. Thus, we can rewrite the VAR in moving average form as:

$$Y_t = \mu + \sum_{i=0}^{\infty} D_i X_{t-i} + \sum_{i=0}^{\infty} \Phi_i U_{t-1} \dots\dots\dots\dots\dots\dots\dots..(iii)$$

Where:

Y_t = GDP
μ = Constant Term
Σ = Covariance Matrix of Shocks
D_i = Dynamic multiplier Function
X_t = Agricultural Productivity Index
Φ_i = Impulse Response Function at Horizon i
U_t = Residual

Where all past values of Y_t have been substituted out. The D_i matrices are the dynamic multiplier functions, or transfer functions. The sequence of moving average coefficients Φ_i are the simple impulse-response functions (IRFs) at horizon i.

IRFs describe how the VAR system reacts over time to one-unit shock in a variable assuming that there is no other shock in the system during that period and measure the effects of a shock to an endogenous variable on itself or on another endogenous variable (Davtyan, 2014).

3.2 Panel Least Square

In order to establish the drivers of agricultural productivity growth; a basis of postulation is derived from Cobb-Douglass production function in line with Brownson *et al*., (2012) in which productivity growth depends on the available physical and human capital and the level of technology. By introducing other endogenous factors, agricultural productivity equation can be expressed as follows:

$$I_nAP_{it} = \alpha_0 + \alpha_1 I_nEXP_{it} + \alpha_2 I_nATB_{it} + \alpha_3 I_nCPI_{it} + \alpha_4 I_nHCAP_{it} + \alpha_5 I_nMACH_{it} + \alpha_6 I_nFERT_{it} + \alpha_7 I_nIRRG_{it} + U_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{(iv)}$$

Where:

AP_t	=	Agricultural Productivity (index)
EXP_t	=	Government Agricultural Expenditure (constant 2005 US dollar)
ATB_t	=	Agric Trade Barrier (index)
CPI_t	=	Consumer Price Index (index)
$HCAP_t$	=	Human Capital (index)
$MACH_t$	=	Farm Machinery (number)
$FERT_t$	=	Fertilizer Consumption (metric tons)
$IRRG_t$	=	Irrigation (hectares)
U_t	=	Error term; all in time t (between-country error)
I_n	=	logarithm form

t = 1980 to 2014.

Equation (iv) is the fixed-effects panel data estimation of the model for this study. Data for each country on the above mentioned eight variables was taken for the period of 1980 to 2014. Different variations with reference to cross-section or time are applied to the fixed effects models. The fixed effects (FE) model has constant slopes but intercepts differ according to the cross-sectional unit (Gujarati, 2003). FE with differential intercepts and slopes can also be applied on data, but inclusion of lot of variables and dummies may give results for which interpretation is cumbersome, because many dummies may cause the problem of multicollinearity (Gujarati, 2003).

FE explore the relationship between predictor and outcome variables within an entity. Each entity has its own individual characteristics that may or may not influence the predictor variables (Bartel, 2008). When using FE, we assume that something within the individual may impact or bias the predictor or outcome variables and we need to control for this. This is the rationale behind the assumption of the correlation between entity's error term and predictor variables. FE remove the effect of those time-invariant characteristics so we can assess the net effect of the predictors on the outcome variable (Bartel, 2008).

Another important assumption of the FE model is that those time-invariant characteristics are unique to the individual and should not be correlated with other individual characteristics (Oscar, 2007). Each entity is different therefore the entity's error term and the constant (which captures individual characteristics) should not be correlated with the others. If the error terms are correlated, then FE is no suitable since inferences may not be correct and you need to model that relationship (probably using random-effects), this is the main rationale for the Hausman test (Oscar, 2007). The fixed-effects model controls for all time-invariant differences between the individuals, so the estimated coefficients of the fixed-effects models cannot be biased because of omitted time-invariant characteristics (Gujarati, 2003)

One side effect of the features of fixed-effects models is that they cannot be used to investigate time-invariant causes of the dependent variables. Technically, time-invariant characteristics of the individuals are perfectly collinear with the entity. Substantively, fixed-effects models are designed to study the causes of changes within an entity. A time-invariant characteristic cannot cause such a change, because it is constant for each person (Oscar, 2007).

The rationale behind random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. The crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not (Greene, 2005).

If you have reason to believe that differences across entities have some influence on your dependent variable then you should use random effects. An advantage of random effects is that you can include time invariant variables. In the fixed effects model these variables are absorbed by the intercept. The random-effects model for equation (iv) above was specified as:

$$I_nAP_{it} = \alpha_0 + \alpha_1 I_nEXP_{it} + \alpha_2 I_nATB_{it} + \alpha_3 I_nCPI_{it} + \alpha_4 I_nHCAP_{it} + \alpha_5 I_nMACH_{it} + \alpha_6 I_nFERT_{it} + \alpha_7 I_nIRRG_{it} + e_{it} + U_{it} \quad \text{(v)}$$

Equation (v) captures both the between-country and within-country errors unlike the fixed-effects model, which captures only the within-country error. In equation (v), the between-country error was captured with e_{it}, while the within-country error was captured by U_{it}.

3.3 Hausman Specification Test

Hausman specification tests the null hypothesis that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. The null hypothesis is that the preferred model is random effects and the alternative is fixed effects (Greene, 2005). Hausman test basically tests whether the unique errors (*ui*) are correlated with the regressors (Greene, 2005).

If they are insignificant, then it is safe to use random effects. If we get a significant P-value, however, we should use fixed effects (Greene, 2005). The Hausman test is a kind of Wald χ2 test with *k-1* degrees of freedom (where *k* = number of regressors) on the difference matrix between the variance-covariance of the least squares dummy variable (LSDV) with that of the Random Effects model.

The Hausman principle can be applied to all hypothesis testing problems, in which two different estimators are available, the first of which βˆ is efficient under the null hypothesis, however inconsistent under the alternative, while the other estimator β˜ is consistent under both hypotheses, possibly without attaining efficiency under any hypothesis. Hausman had the intuitive idea to construct a test statistic based on q = βˆ − β˜. Because of the consistency of both estimators under the null, this difference will converge to zero, while it fails to converge under the alternative.

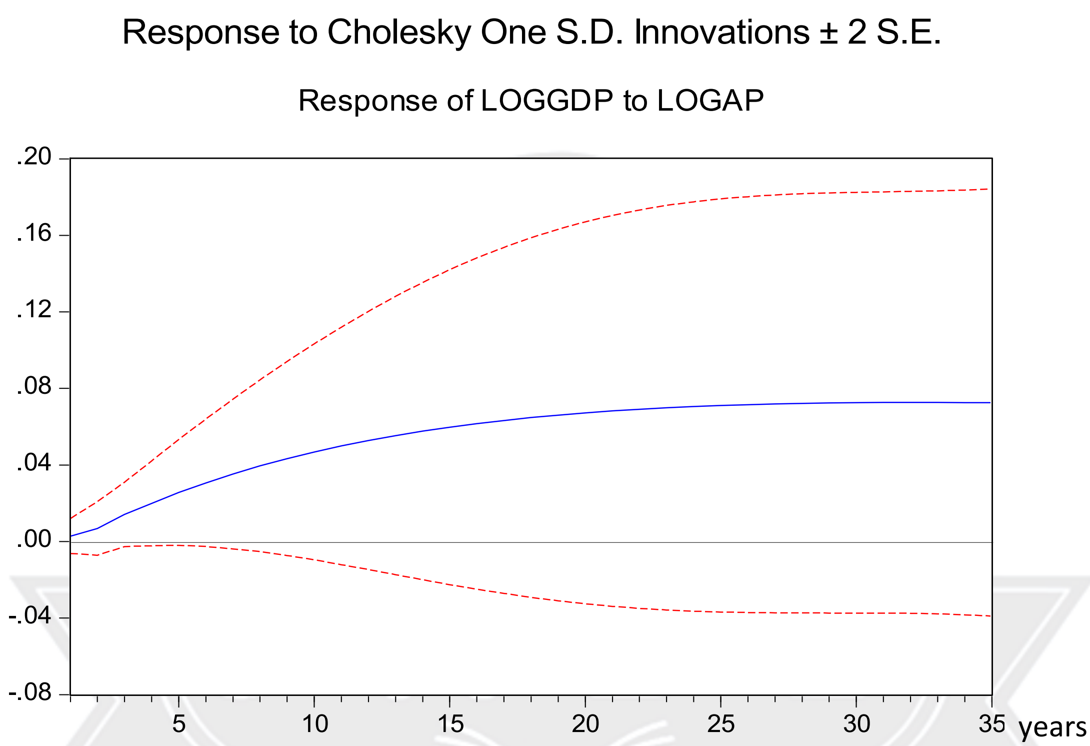
4 RESULTS AND DISCUSSION

4.1 Impulse Response Function (IRF) Analysis

The result of the IRF is presented in Figure 1. The horizontal axis on the graph shows time period (a year, in this case). Points on the graph above zero display positive responses, while points below zero represent negative responses. In this study, the average cross-sectional values of AP and GDP for the 35 countries were transformed to logarithms because this can transform the data to percentage changes and make interpretation of the results, such as elasticity, more economically meaningful. The figure shows the 95% level of confidence from the confidence bands, the upper dotted line represents the upper confidence band, while the lower dotted line represents the lower confidence band and the middle solid line (point estimate) shows IRFs.

By using the point estimate (the solid line) in Figure 1, it was observed that one standard deviation positive shock to agricultural productivity (AP), will leads to 0.003, 0.026, 0.047 and 0.073 percentage point increase in GDP in agriculture-based economy in the first, fifth, tenth and thirty fifth year, respectively. The positive response of GDP to a given shocks in AP increase at a positive rate throughout the thirty fifth period, thus AP shock has a stable positive effect on GDP in agriculture-based economy.

This result satisfies *a priori* expectation that agricultural productivity can be a greater engine for driving growth in agriculture-based economy. These findings conform with the view of World Bank (2008) and corroborated the earlier findings of Oyinbo and Zibah (2014) and Cao and Birchenall (2013) who found that agriculture can be the main engine of growth in agriculture-based economy.



NB: Solid lines: impulse response; dashed lines: 95% confidence bands

Figure 1: Impulse Reaction Functions of GDP to AP Shock in Agriculture-Based Economy

4.2 Panel Least Square

4.2.1 Panel Unit Root Test

All the panel variables were subjected to stationarity test using Levin-Lin-Chu tests. The results of these tests as reported in Table 3 showed that some variables are stationary at their levels, while others at their first difference.

4.2.2 Panel Cointegration Test

The result of the Johansen-Fisher Panel Cointegration test is presented in Table 4, we compare Fisher trace test and Fisher max-eigen test, at most 7 variables has a long-run relationship in both cases. The Johansen-Fisher Panel Cointegration test in both cases showed that for every case at 5% level of significance, we reject null hypothesis of no cointegration. Thus, P-value which are highly significance at 1% level gives strong evidence that those variables have a long-run relationship.

Table 3: Panel Unit Root Test

Variables	Level	First Difference	Order of Integration
AP_t	-1.28599	-11.2970***	I (1)
ATB_t	-0.45544	-16.1721***	I(1)
CPI_t	-4.73261***	-	I(0)
EXP_t	5.12633	-19.0781***	I(1)
$FERT_t$	0.82558	-19.0440***	I(1)
$HCAP_t$	-1.91554**	-	I(0)
$IRRG_t$	-2.93592***	-	I(0)
$MACH_t$	-5.79790***	-	I(0)

NB: (***) and (**) denote statistical significance at 1% and 5% level, respectively
Source: Author's Computation (2017)

Table 4: Johansen Fisher Panel Cointegration Test

Series	Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
AP,	None	886.7	0.0000	362.2	0.0000
ATB,	At most 1	480.7	0.0000	197.8	0.0000
CPI,	At most 2	308.4	0.0000	118.4	0.0000
EXP,	At most 3	203.9	0.0000	80.79	0.0000
HCAP,	At most 4	140.3	0.0000	56.88	0.0082
MACH,	At most 5	105.3	0.0000	49.16	0.0447
FERT,	At most 6	87.57	0.0000	62.39	0.0021
IRRG	At most 7	84.97	0.0000	84.97	0.0000

* Probabilities are computed using asymptotic Chi-square distribution.

Source: Author's Computation (2017)

4.2.3 Fixed Effects and Random Effects Result

The results of both the fixed-effects model and random-effects model are presented in Table 5. However, our interpretation of empirical results is based on the fixed-effects model because of the outcome of the Hausman specification test, which points to the rejection of the null hypothesis, an indication that fixed-effects model is more appropriate and random effects is inconsistent.

Taking a descriptive examination of the panel least square as reported in Table 5. The estimated fixed effects coefficient of determination (R-squared) is 75%. This indicates that the model explained about 75% of total variance in AP for agriculture-based economy. This confirmed the goodness of fit of the model. The F-statistic result of the fixed effects with their probability value shows that these explanatory variables are jointly significant in explaining the variation in the dependent variable.

From Table 5, we observed that the coefficient of IRRG is positive and statistically significant at 1% significance level. This study revealed that a 1% increase in irrigation facilities will increase the level of agricultural productivity (AP) by about 0.0974% in agriculture-based economy. This is in agreement with the findings of Enrique *et al.* (2010); Songqing et al. (2012); Himayatullah and Mahmood (2012) and Srivastava et al. (2013). Therefore, it can be deduced from this study that irrigation has played a catalytic role by positively contributing to agricultural productivity.

As can be seen from the same Table 5, the coefficient of fertilizer (FERT) is negative and statistically significant at 1% significance level. The estimated coefficients signify that 1% increase in fertilizer usage will lead to 0.0313% decrease in AP in agriculture-based economy. This observation does not conform to *a priori* expectation because fertilizer is expected to boost agricultural productivity thus the results from this study indicate that increasing the use of inorganic fertilizer generated negative impact on TFP either through deterioration of soil fertility or crop destructions attributable to detriments of chemical fertilizers. This observation might also be traceable to continuous application of fertilizers on farm land which reduce the activities of soil organisms and hinder the growth of crops.

This outcome might be traceable to the fact that majority of farmers in developing nations apply fertilizers to soils without soil testing which could lead to under fertilization or excessive nutrient build up in the soil – a scenario that can adversely affect soil chemical and physical properties. These will generally affect soil productivity, subsequently leading to low yields. Overall, continuous application of fertilizers may have adverse effects on soil health, plant growth and quality, and the environment. So, optimum and balanced fertilization or integrated nutrient management based on soil test and crop requirement is advisable for sustainable agricultural productivity.

This finding supports the earlier findings of Ritwik and Sayed (2015) who also revealed that continuous usage of inorganic fertilizer has adversely reduce agricultural total factor productivity. Conversely, the finding of Fulginiti *et al.* (1998), Khalil and Anthony (2012) was not in agreement with this finding.

The coefficient of consumer price index (CPI) is positive with a significant t-statistic at 1 significance level in agriculture-based economy. This observation contravenes the economic theory that postulates inverse relationship in agricultural production and inflation. The implication of this finding is that when the rate of inflation increases and purchasing power of a currency decreases, agricultural productivity will increase. This finding is not consistent with economic theory because it is expected that an increase consumer price index (decrease in purchasing power of currency) will increase the cost of farm input and decrease agricultural productivity. This finding might be connected to rapid increment in food prices and other agricultural commodities that motivate farmers to maximise their output with constant input. And again, when the price of farm input rises during inflation period, farmers technically reduced their input cost while keeping their output constant.

Finally, the coefficient of machinery (MACH) is positive and significant at 1% significance level in agriculture-based economy. This outcome met *a priori* expectation, the implication of this is that additional usage of machinery will go a long way to boost agricultural productivity in agriculture-based economy. Farm machinery helps farmers to reduce the amount of farm labour, encourages large scale farming and thus increases farmers marginal output.

Table 5: Panel Least Squares Results of Drivers of Agricultural Productivity

Variable	Fixed Effects	Random Effects
LOGATB	0.004766 (0.355293)	-0.005968 (-0.449447)
LOGCPI	0.032684*** (6.388893)	0.036749*** (7.810052)
LOGEXP	0.001461 (0.405883)	0.002725 (0.772431)
LOGFERT	-0.031346*** (-2.856002)	-0.029533 (-2.787665)***
LOGHCAP	0.159955 (1.844019)	0.360999 (4.935041)***
LOGIRRG	0.097390*** (7.165380)	0.038379 (3.535289)***
LOGMACH	0.090050*** (6.563905)	0.038510*** (3.411771)
C	3.520582*** (24.04022)	4.115935 (32.85496)***
R-squared	0.751001	0.461842
Adjusted R-squared	0.740972	0.455424
F-statistic	74.87761***	71.96530***
Hausman Test	77.217521***	

NB: (***) and (**) denote statistical significance at 1% and 5% level respectively. The number in parenthesis are the t-statistics value.

Source: Author's Computation (2017)

5 CONCLUSION AND RECOMMENDATIONS

This study examined the factors influencing agricultural productivity in agriculture-based economy. Overall, the study found that irrigation significantly increased agricultural productivity in agriculture-based economy. In contrary, the study revealed that fertilizer significantly decreased agricultural productivity. The evidence provided in this study showed that consumer price index and farm machinery significantly increased agricultural productivity in agriculture-based economy. This study therefore concludes that agricultural productivity will grow in agriculture-based economy with an expansion in irrigation application and additional use of farm machinery. Improved irrigation infrastructure that will enhance smallholder farmers capacity for all-season cropping and additional use of farm machinery should be implemented for increased agricultural productivity.

Recommendations

i. The study recommends improved irrigation infrastructure that will enhance small scale farmers for all-season cropping, evolving institutional rearrangements, developing sustainable groundwater supply and emphasizing on completion of the on-going irrigation projects efficiently rather starting new ones.

ii. It is worthy of note that fertilizer use has significantly decreased agricultural productivity in agriculture-based economy. This study therefore recommends appropriate application of fertilizer and integrated nutrient management based on soil test and crop requirement for sustainable agricultural productivity. This can be complemented by promoting farmers' use of improved crop management practices such as crop rotation with legumes, changes in density and spacing patterns of seeds, early planting, timely weeding, and other conservation farming methods.

iii. There was evidence of increased agricultural productivity with additional use of machinery in agriculture-based economy. This study therefore recommends that government in agriculture-based economy should procure more farm machineries and make same available for farmers at a subsidize rate. This can be supplemented by development of more innovative institutions like co-operatives, self-help groups that will provide a better financial and support services to the small and marginal farmers for mechanization of their farm which will enhance agricultural productivity.

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