Modelling the effect of public investment on agricultural productivity in Ghana

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Abstract

Using annual time series data for Ghana, the current study investigates the public investment and agricultural productivity nexus for the period 1961-2013. The empirical assessment is done by using the Johansen test (JT), the Vector Error Correction Model (VECM), and the Ordinary Least Squares (OLS) regression test. The results indicate significant stable long run link between public investment and agricultural productivity in the JT. However, there is insignificant short run link between public investment and agricultural productivity in the VECM. The results of the OLS indicate negative significant link between investment and agricultural productivity. The findings suggest that Public investment has led to a decrease in agricultural productivity. Policy makers should manage public investment very well in order to achieve positive impact on the agricultural sector. The argument in support of public investment in agriculture sector needs to be re-examined as the current findings does not support the debate. Future study should examine the current issue using accounting for causality and structural breaks issues since the present study did not consider these issues.

Jel Codes: H54, Q20, Q58
Keywords: Agricultural economics, public investment, agricultural sector, economic growth, long run, short run.

1.1 Introduction

The effect of public investment on agricultural productivity has attracted attention in the literature in all economics over the years as a results of the important role of agriculture in the economic development of a country (Nadeem, Mushtaq & Dawson, 2013; Benin, Mogues, Cudjoe, & Randriamamonjy, 2009; Diao et al., 2007; Anderson, de Renzio, & Levy 2006). Improvement in Agriculture leads to provision of food, income and poverty reduction (Evenson, 2001).

Theoretically, many reasons account for the need for public investment in agriculture (Gockowski & Sonwa, 2011; Lewis, Barham, & Zimmerer, 2008; Anderson et al., 2006; Kakwani & Son, 2006; Costas & Stachuriski, 2005; Malla & Gray, 2005; Kydd & Dorward, 2004; Bourgeon and Chamber, 2003; van de Walle, 2003; Meinzen-Dick et al., 2002; Barnes, 2001; David et al., 2000; Figlio, Kolpin, Reid, 1999; Shiferaw & Holden, 1999; Lopez, 1997; Skees, Black, & Barnett, 1997; Foster & Rosenzweig, 1996; Case et al., 1993; Ramaswami, 1993; Greene, 1993; Oates & Schwab, 1988; Nelson & Loehman, 1987; Maddala, 1983; Ahsan, Ali, and Kurian, 1982; Rosenstein-Rodan, 1943) with the findings not been conclusive.

Among the reasons public investment is supported in the theoretical literature are efficiency resulting from market failures, unregulated market space which might lead to decrease aggregate income and worsen welfare of the citizens, poor coordination of the production process which might results in lower output in the agriculture sector. All these might create inefficiency in the agriculture sector and that calls for support in the agriculture sector (Anderson et al., 2006). Public investment is supported in the agriculture sector for equity argument to avoid inequalities in the economy in order to narrow the gap between the rich and the poor. Poverty reduction in addition to efficiency argument and equity is supported for public investment since the agriculture sector helps in poverty reduction.

The findings of empirical works are found in the works of various researchers (Pratt & Fan, 2010; Kiani, 2008; Fan et al., 2004; Ali, 2005; Ashipala & Haimbodi, 2003; Fan, 2000; Fan et al., 2000; Makki et al., 1999; Fernandez-Cornejo & Shumway, 1997; Devarajan et al., 1996; Rosegrant & Evenson, 1993; Chavas & Cox, 1992; Evenson & Bloom, 1991; Nagy, 1991).The findings have been inconclusive in the empirical literature. Whereas some previous studies report of significant effect of public investment on agricultural productivity (Benin et al., 2009; Diao et al., 2007; Ashok & Balasubramanian, 2006; Huffman & Evenson, 2006; Kiani, 2008; Ali, 2005; Fan & Rao, 2003; Fan et al., 2000; Binswanger et al., 1993; Leinbach, 1983;) others report of lowering effect of public investment on agricultural productivity (Ashipala & Haimbodi, 2003; Devarajan et al., 1996). The findings of both theoretical and empirical works produce mixed findings and that calls for further empirical studies to add to the literature on the effect of public investment on agricultural productivity.

There has been public investment in the agriculture sector over the years with the view of increasing agricultural productivity. The performance of the agricultural sector and its contribution to the economic growth of the country have not been sustainable over the years. For example, in 2007, the growth rate was -1.7%; in 2008, the rate was 7.4%; in 2009, the rate was 7.2%; in 2010, the rate was 5.3%; in 2011, the rate was 0.8%; in 2012, the rate was 2.3% and in 2013,the rate was 5.2%. The contribution of the agriculture sector to the economy growth of Ghana continues to be unsustainable and in addition decline, with its share reducing from 23.0 percent in 2012 of GDP to 22.0 percent in 2013. In the face of the unsustainable nature of the agriculture sector, the sector continues to attract public investment.

Previous works (Nadeem et al., 2013; Benin et al., 2009; Anderson et al., 2006) that have examined the effect of public investment on agriculture production with mixed findings and few on the developing economies. The current research empirically examines the nexus between public investment and agricultural productivity. The current paper is motivated by the few empirical works, especially, on developing economies, and the inconclusive theoretical and empirical works reported in the literature.

The general objective of the paper is to contribute empirically to the body of knowledge in the area of agricultural productivity by modelling the link between public investment and agricultural output. Specifically, the long run and short run effects of public investments on agricultural productivity are examined.

The research questions underlying the paper are as follows: (1) what is the nature of short run link between public investment and agricultural productivity? (2) What is the nature of long run nexus between public investment and agricultural productivity? The paper is based on the assumption that public investment have significant effect on agricultural productivity in the short run and the long run. The rest of the paper focuses on the research methodology, results and analysis, discussions, conclusions, and policy implications.

2. Methodology

The paper is based on a quantitative research design which is appropriate to explain the link between public investment and agricultural productivity. The nexus between investment and agricultural productivity is quantified and explained in the current paper. The paper is based on a time series model as specified in equation (1). The dependent variable in equation one is agricultural productivity (AP), whereas the explanatory variable is public investment (PIV). The estimation methods for the paper are Johansen model, the Error Correction model and the OLS regression. The Johansen test is used to examine the stable long run nexus between public investment and agricultural productivity. The error correction model (ECM) is used since it allows for the examination of the short run adjustment to the long run equilibrium. Since time series data are use, the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test and the augmented Dickey-Fuller (ADF) test are used to examine the stationarity properties of the series. The paper is based on annual time series data covering the periods 1961 to 2013 for Ghana. Data was obtained from World Development Indicators (WDI). The number of observations are 54. This is a large sample size since it is greater than 30 for estimation.

$$\ln AP_t = \alpha_t + \beta_t \ln PIV_{t-1} + \varepsilon_t \text{..........................(1)}$$

3. Empirical Results

3.1 Summary Statistics

Table 1 provides a summary statistics of the test variables. The means measure the central tendencies and the values indicate a good fit. The coefficients of variation measure the volatility of the series. The results indicate that agricultural productivity (0.22) is less volatile than public investment (0.46). Public investment falls as low as 3.38 and as high as 31.78, whereas agricultural productivity falls as low as 23.15 and as high as 65.04. The standard deviation measures the dispersion of a set of data from its mean. The more spread apart the data, the higher the deviation. The results indicate that agricultural productivity (9.77) is more spread from the mean than public investment (7.46).The coefficient of Skewness measures the nature of distribution of the series. The results in Table 1 shows agricultural productivity is negatively skewed (-0.22) whereas public investment is positively skewed (0.08). The coefficient of kurtosis measures the nature of peakness. The values (-1.02) and (-0.26) are less than zero and indicate more flat-topped distribution.

Table 1 Descriptive Statistics

Summary Statistics, using the observations 1905/05/14 - 1905/07/05				
Variable	Mean	Median	Minimum	Maximum
PIV	16.33	15.88	3.38	31.78
AP	45.09	45.05	23.15	65.04
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
PIV	7.46	0.46	0.08	-1.02
AP	9.77	0.22	-0.22	-0.26

Source: Author's calculation from data collected from WDI, 2016

3.2 Time Series Plots of Public Investment (PIV) and Agriculture Productivity (AP)

Figures 1 to 4 show the time series plots for PIV and AP. Figure 1 indicates public investment is non-stationary in levels. However, figure 2 indicates the series attained stationarity on first difference. Figure 3 shows agriculture productivity (AP) is non-stationary in levels. However, the agricultural productivity attain stationarity on first difference as shown in figure 4. This calls for formal investigation of the nature of stationarity properties of the series using the ADF and KPSS.

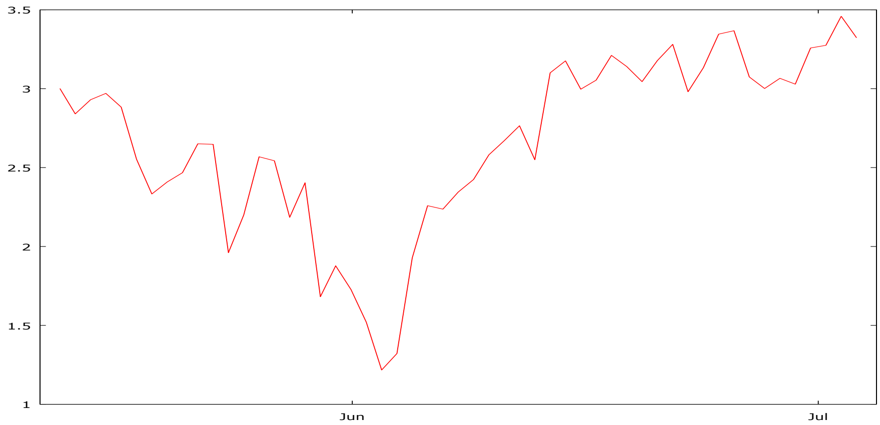

Fig 1. Time series Plot of lnPIV (Proxied by gross fixed capital investment, GCF) in level

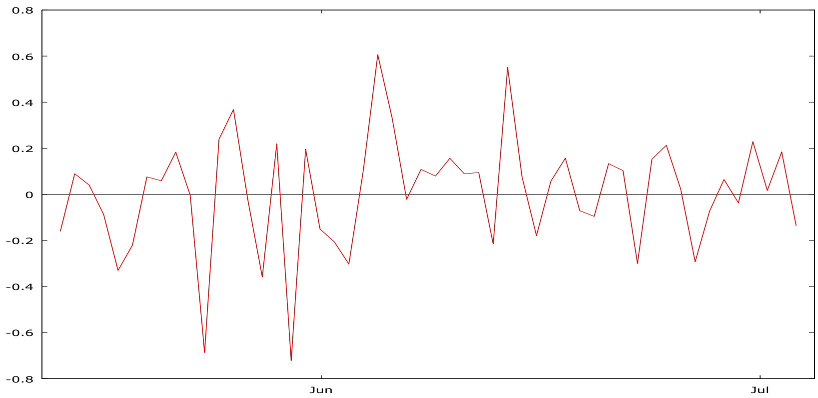

Fig 2. Time series Plot of lnPIV (Proxied by gross fixed capital formation, GCF) in first difference

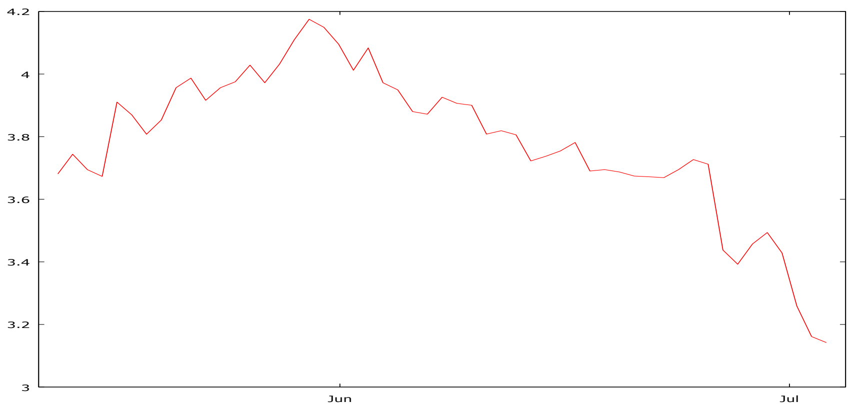

Fig 3. Time series Plot of lnAP (Proxied by Agricultural value added, AVA) in level

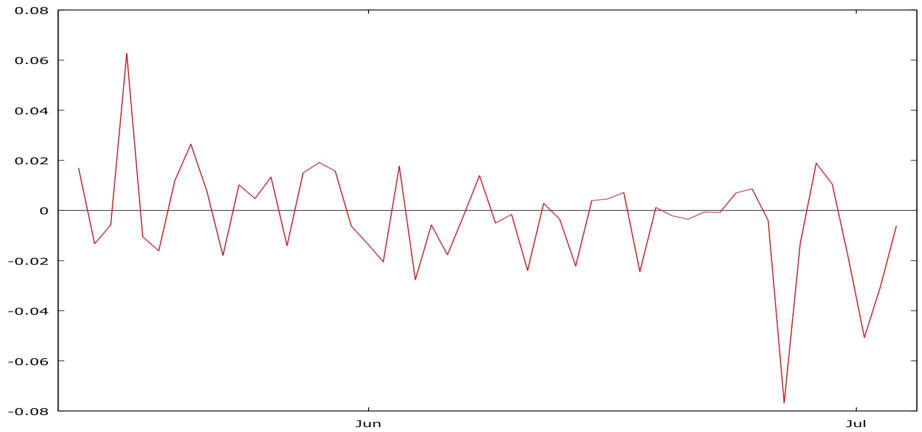

Fig 4. Time series Plot of lnAP (Proxied by Agricultural value added, AVA) in first difference

3.3 Stationarity Test

The results of the ADF test and KPSS test for stationarity are reported in Table 2 and Table 3. The results show the series are non-stationary in levels. However, the series attained stationarity on first differencing.

Table 2 ADF Stationarity Test Results with a Constant and a Time Trend

Variables	ADF-value	T-statistics	P-value	Results	Max Lag
lnPIV	-0.165	-2.347	0.402	Not Stationary	1
lnPIV-1st dif.	-1.08978	-7.54327	2.797e-007	Stationary	1
lnAP	-0.118332	-1.69594	0.7534	Not Stationary	10
lnAP-1st dif.	-1.87282	-6.56721	4.044e-008	Stationary	10

Source: Author's calculation from data collected from WDI, 2016

Table 3 KPSS Stationarity Test Results with a Constant and a Time Trend

Variables	KPSS-value	Results	Max Lag
lnPIV	0.236442	Not Stationary	3
lnPIV-1st dif.	0.0905762	Stationary	3
lnAP	0.300993	Not Stationary	3
lnAP-1st dif.	0.0629141	Stationary	3
Critical values:	10% 5% 1% 0.121 0.149 0.213		

Source: Author's calculation from data collected from WDI, 2016

3.4 Regression Results

3.4.1 Johansen Test Results

The results on the examination of the long run relationship between public investment and agricultural productivity are reported in Table 4. The results show that there is significant long run nexus between agricultural productivity and public investment using the Johansen method, since both the trace test and the maximum Eigen value test passed the stable long run test. The error correction (ECM) used to examine the short run relationship between agricultural productivity and public investment. The results indicate that there is still disequilibrium in the short run since the error correction term (ECM-1=0.139; p=0.345) is not significant. The value does not have the expected a priori theoretical sign of negative. The value is not correctly signed. The positively signed valued means that the nexus between public investment and agricultural productivity has the tendency to explode over time, though insignificant. The value indicate that only about 13.9% of errors generated in the previous period is corrected in the current period for the agricultural productivity equation.

Table 4 Johansen Cointegration Test Results and the Vector Error Correction Results

Number of equations = 2 Lag order = 7 Estimation period: 1905/05/22 - 1905/07/05 (T = 45)					
Rank	Eigen-value	Trace Test	P-value	L-Max Test	P-value
r=0	0.261	15.392	0.050**	13.621	0.061*
r=1	0.039	1.772	0.183	1.772	0.183
Variable	Coefficient	Std. Error	T-Ratio	P-value	
ECM_{-1}	0.139	0.145	0.959	0.345	
Mean dependent var	-0.014	S.D. dependent var	0.070		
Sum squared resid	0.143	S.E. of regression	0.067		
R-squared	0.353	Adjusted R-squared	0.091		
rho	0.030	Durbin-Watson	1.891		

Source: Author's Calculation from Data Collected from WDI, 2016. Note ** and * denote significance at 5% and 10% levels of significance.

3.4.2 OLS Regression Results

Since there is stable long run relationship between agricultural productivity and public investment, the OLS regression was used to estimate the elasticity coefficients. The results are reported in Table 5. The result shows that public investment is negatively related to agricultural productivity. The results indicate that 1% increase in public investment leads to about 32.7% decrease in agricultural productivity. The values of the R^2 and adjusted R^2 in Table 5 are indication of a well behaved model. The results indicate that about 58.6% of the changes in agricultural productivity equation is accounted for by the estimated model.

Table 5 OLS Regression Results

OLS, using observations 1905/05/14-1905/07/05 (T = 53): Dependent variable: lnAVA					
Variable	Coefficient	Std. Error	T-ratio	P-value	
Const	4.654	0.103	45.183	<0.00001	***
lnGCF	-0.327	0.038	-8.633	<0.00001	***
Mean dependent var	3.783	S.D. dependent var	0.236		
Sum squared resid	1.173	S.E. of regression	0.152		
R-squared	0.594	Adjusted R-squared	0.586		
F(1, 51)	74.526	P-value(F)	1.51e-11		
Log-likelihood	25.769	Akaike criterion	-47.539		
Schwarz criterion	-43.598	Hannan-Quinn	-46.024		
rho	0.801	Durbin-Watson	0.491		

Source: Author's Calculation from data Collected from WDI, 2016. Note *** denotes significance at 1% level.

3.4.3 Results of Diagnostic and Stability Tests

Table 6 reports the results of the diagnostic tests of the OLS regression to examine the reliability of the estimated coefficients. The estimated model fail to pass all the diagnostic tests performed. The tests are specification test, heteroskedasticity, normality test, and autocorrelation tests. This is an indication that the coefficients are not reliable and also not stable.

Table 6 Diagnostic Test Results of OLS Regression

A. Reset Test for Specification
Null Hypothesis: Specification is Adequate Test statistic: F(2, 49) = 6.853 P-value = P(F(2, 49) > 6.853) = 0.002
B. Breusch-Pagan Test for Heteroskedasticity
Null hypothesis: Heteroskedasticity not present Test statistic: LM = 3.884 P-value = P(Chi-square(1) > 3.884) = 0.049
C. Test for Normality of Residual
Null hypothesis: Error is Normally Distributed Test statistic: Chi-square(2) = 11.984 P-value = 0.00249897
D. LM Test for Autocorrelation up to order 7
Null hypothesis: No Autocorrelation Test statistic: LMF = 9.395 P-value = P(F(7,44) > 9.395) = 4.5551e-007
E. CUSUM test for Parameter Stability
Null hypothesis: No Change in Parameters Test statistic: Harvey-Collier t(50) = -2.991 P-value = P(t(50) > -2.99083) = 0.004

Source: Author's Calculation from data Collected from WDI, 2016.

The stability tests results as shown (CUSUM and CUSUMSQ) in figures 5 and 6 revealed that, the estimates and the variance as well as the residuals and the square residual are not stable, since they fall outside the 5% critical boundaries. The null assumptions of parameter stability are rejected in both tests.

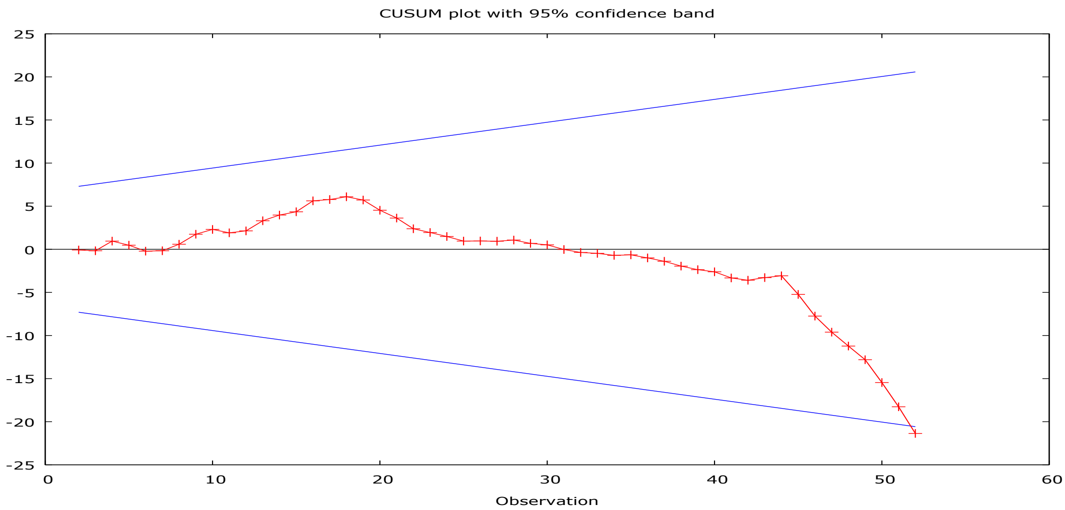

Figure 5 Plot of CUSUM

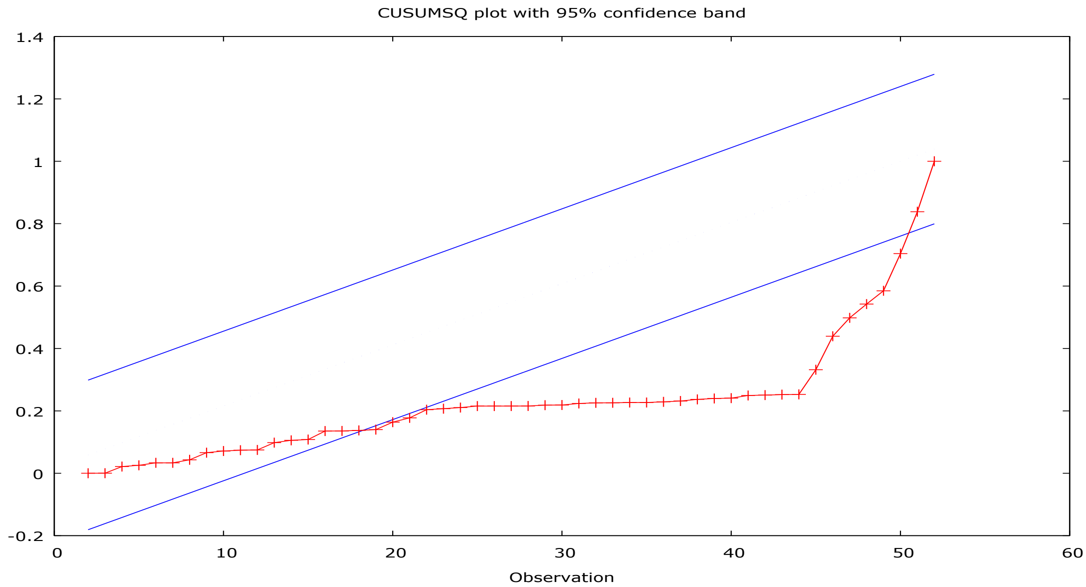

Figure 6 Plot of CUSUMSQ

4. Discussions

The findings from the stationarity test indicate that public investment and agricultural productivity are non-stationary in levels. The findings are in support of previous studies such as Ramirez (2012) for Argentina where public investment was found to be non-stationary. The findings of non-stationarity of the agricultural productivity is in support of that of Ali et al (2012) for Iran. The implication of the findings is that, there is permanent and not temporary effect of shock to public investment and agricultural productivity in Ghana for the period under discussion. The theories of unit root in relation to time series data are confirmed. Regression analysis using public investment and agricultural productivity time series data should account for stationarity to achieve robust results. Policies designed to improve agricultural productivity will have lasting effects. The effectiveness of policies aimed at inducing negative shocks to agricultural productivity and investment will displace agricultural productivity and investment from the long run growth path.

The study shows that public investment and agricultural productivity are linked in the long run. Changes in agricultural productivity are explained by changes in public investment in the long run. The findings from the OLS results indicate that there is negative link between agricultural productivity and public investment. The findings support the previous studies by researchers such as Ashipala and Haimbodi (2003) and Devarajan et al. (1996) who reported that public investment lower agricultural productivity productivity. However, the findings are inconsistent with that of Benin et al. (2009), Diao et al. (2007), Ashok and Balasubramanian (2006), Kiani (2008), Huffman and Evenson (2006) and Ali (2005) who reported of significant positive effect of public investment on agricultural productivity. The theories on the argument for the support of public investment in agricultural sector are not supported here, since public investment have negative effect on agricultural productivity (Gockowski & Sonwa, 2011; Lewis, Barham, & Zimmerer, 2008; Anderson et al., 2006; Kakwani & Son, 2006; Costas & Stachuriski, 2005; Malla & Gray, 2005).

5. Conclusions and Policy Implications

Given the importance of the agricultural sector to an economy, the current study investigates the public investment-agricultural productivity nexus for Ghana for the period 1961-2013, using annual time series data. The empirical assessment was done by using the JT, VECM, and the OLS regression. The results indicate significant stable long run link between public investment and agricultural productivity. However, there is insignificant short run link between the two variables. The results of the OLS indicate negative significant link between investment and agricultural productivity. The results suggest public investment during the period under consideration has led to a decrease in agricultural productivity. The policy implication is that public investment must be managed very well in order to achieve positive impact on the agricultural sector. The argument in support of public investment in agriculture in developing economic such as Ghana needs to be re-examined as the current findings does not support the debate.

Future study should examine the current issue in causality modelling, and in addition, accounting for structural breaks, since the present study did not consider these issues. The current study is based on bivariate analysis. The findings are limited by the use of bivariate models since such models are criticized for omitted variable bias. Future study should consider multivariate analysis to determine if the findings will be replicated, and also to address the issue of omitted variable bias. Predictive conclusions could in addition, not be made since causality issues are not considered.

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