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NEXUS BETWEEN INVESTMENT AND AGRICULTURAL GROWTH IN THE DEMOCRATIC REPUBLIC OF CONGO: COINTEGRATION, SHORT-RUN DYNAMICS AND CAUSALITY

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Abstract. This paper aims to assess the impact of agricultural investment on agricultural output in the Democratic Republic of Congo using secondary data for the period 1980 to 2019. Using the Johansen and Jusseleus cointegration test, agricultural investment and agricultural output were observed to have a statistically significant long-run relationship. Additionally, the error correction model (ECM) shows that the short-run coefficient of agricultural investment has a statistically significant positive impact on agricultural output, implying that investment (machine, infrastructure etc.) does spur agricultural output in the Democratic Republic of Congo. The results show the presence of unidirectional causality between agricultural output toward agricultural investment. It was also observed that unidirectional causality from labour force to agricultural investment, labour force to education and agricultural investment to land use and a bi-directional causality between land use and labour force exists. The paper concludes that an increase in investment in the agricultural sector will result in agricultural output in the Democratic Republic of Congo.

Keywords: agricultural growth, agricultural investment, cointegration, granger causality, VECM, the Democratic Republic of Congo

INTRODUCTION

The development of the agricultural sector in Less Developed Countries (LDCs) is one of the most debated new topics in the world. Many texts have shown theoretically that the agricultural sector occupies an important place in the economic emergence of developing countries (Vylder et al., 2007; Huq et al., 2003; Panagaria, 2005 and Bellman and Hepburn, 2017). In developing countries, agriculture is the backbone of the economy and the sector represents 23 percent of sub-Saharan Africa's GDP and more than 60 percent of its population is made up of smallholder farmers (Goedde et al., 2019). In these countries, 70% of the poor population lives in rural areas and most of them depend directly or indirectly on agricultural activity for their main income (Kanza and Vital, 2015).

A review of the literature suggests that several studies have been conducted to investigate the determinants of agricultural output, such as land, labour, education and capital, among others, to promote agricultural output growth. For example, Ball et al. (1993) and later Nabieva and Davletshina (2015), examined gross capital investment in India and Tatarstan, respectively, and found that agricultural investment could increase market value by keeping food prices lower and accessible to rural and urban consumers.

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The neoclassical theory, through the output function, showed that technology and a production mechanism were directly related. The Cobb-Douglas function was introduced by some pioneers of econometrics from the field of agricultural economics; the most recent contributions are those of Fox (1986), Banzhaf (2006) and Rutherford (2009). The new growth theory emphasizes technological change as the result of economic processes embedded in machinery and equipment, unlike Solow's model. The increase in production funds *per capita* cannot influence the growth of labour productivity in time, nor affect significant differences in the growth rates of gross domestic product per capita in different countries (Sredojević et al., 2016:180).

The purpose of this paper is to explore the nexus between investment and agricultural growth using desegregated data in the DRC. Thus, the paper hypothesises that there is a positive and statistically significant relationship between agricultural gross capital formation and agricultural output in the DRC. Specifically, we aim (1) to examine the deterministic relationship between agricultural gross capital formation and agricultural output in the Democratic Republic of Congo; (2) to evaluate the long-run equilibrium relationship between agricultural gross capital formation and agricultural output in the DRC; (3) to estimate the short-run relationship between agricultural gross capital formation and agricultural output in the Democratic Republic of Congo.

The rest of the paper is presented as follows. Section 2 presents the literature review. Section 3 discusses the data and methodology. Section 4 presents the results and section 5 concludes.

LITERATURE REVIEW

This section provides a theoretical background to agricultural investment and growth nexus in the agricultural sector. The purpose of this paper is to discuss the theoretical and empirical literature upon which this study is based.

Kulyk and Grzelak (2018:268) used the perspective of M. Kalecki's investments business cycle theory in agricultural investment, from 2007 to 2013. In their study, the integration of mechanization (tractor, means of transport, equipment tools) in the agricultural sector for the study countries of the European Union makes this sector more dynamic. Bathla and Dubey (2017:6) highlight that private and public investment, as well as a favourable motivation structure and infrastructure development, positively impact income in the agricultural sector. According to Mogues (2015:452), support for public investment is not enough to improve performance in agricultural sector, which is why investment in infrastructure and human capital in rural areas is necessarily important.

Jensen et al. (1993: 295–306) conducted an analysis using neoclassical, accelerator and internal cash flow variables. They used a sample of 552 farmers collected from the Kansas Farm Management Association for a period of 16 years, i.e., from 1973 to 1988; the result of this paper, in terms of elasticity, indicates that the investment is more sensitive to internal cash flows than accelerator or neoclassical variables. Agency theory, q-Tobin's theory, adjustment cost theory or Euler's approach emphasize that intervention of public subsidies make investment positive and can alleviate short-term capital market imperfections, so long-term product sales and sufficient cash flow for investment are essential (Grzelak and Kułyk, 2020: 319). Dorward et al. (2004:80) argue that climate change can influence the increase or decrease in the production of domestic goods, thus leading to variations in market prices between import and export. If these price changes are above the threshold of profitability of investment in agricultural intensification, such as the use of fertilizers, then these investments can be reduced by both lower average returns on investments and by the risks.

In an area with relatively good economic development, farmers might have enough employment opportunities to earn off-farm income, given the relatively inefficient agricultural output and the relative shortage of labour (Qian et al., 2015). Matahir (2012) applies the context of time series to analyse the causal relationship between the agriculture and industrial sectors in Malaysia. Regarding sectorial productivity, causality tests show a unidirectional causality from industrial to agricultural sectors both in the short and long run; thus, the agricultural sector could be one of the engines of economic growth. Many early authors (Lewis, 1954; Jorgenson, 1961, Ruttan and Hayami, 1973 and Chatelus, 1979) emphasized that owing to its influence on resources and its capacity to assess, agriculture is the most profitable industrial sector.

In growth theory, technological change is determined as being a unit of measurement to evaluate the new innovation processes on the output function of a firm or a nation. Miao-miao et al. (2015) in their findings demonstrate that there is a long-run equilibrium cointegration between financial development, technological innovation and economic growth, with China's technological innovation thus causing economic growth.

In their contributions, Ncanywa and Makhenyane (2016: 278) use the Johnsen (1988) cointegration test and the vector error correction model (VECM) to analyse the effect of investment on South Africa's economic growth. The results obtained show that gross capital investment has a positive impact on economic growth in the short-term and long-term. Ncanywa and Makhenyane (2016: 278) add that there is evidence of a two-way causality between gross capital investment and economic growth in South Africa.

MATERIALS AND METHODS

Data

The aim of this paper is to assess the link between investment and the growth in the agricultural sector of the Democratic Republic of Congo. Agricultural output, agricultural investment proxy of agricultural gross fixed capital formation and agricultural land use were obtained from the Food and Agricultural Organization (FAO) and labour force and education level were taken from World Bank Indicators (WDI) for the period of 1980 to 2019, i.e., a sample size of 40 years.

Methodology

To specify whether there is a relationship between agricultural investment and agricultural output, the Cobb Douglas function, ordinary last square (OLS), is determined to analyse the character and pattern of links between the variables. The fundamental properties of the data were examined using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). The Johansen-Josseleus cointegration test is used to estimate the long-run relationships between variables, and the error correction model is indicated for the short-run relationships between the variables.

Unit Root Test

The steps in testing the relationship between agricultural investment and agricultural output are based on the stationary properties of the time series. To test the existence of unit root in the series, this paper will use two static tests: the Augmented Dickey-Fuller and Phillips-Perron tests. However, the series will be studied in natural logarithm in order to attenuate their possible volatility. Augmented Dickey-Fuller is the one of most famous tests; this test is the most common method for examining the unit root and used by Dickey and Fuller (1979). The ADF test is presented as follow:

$$\Delta Y_t = \beta + \lambda t + \phi y_{t-1} + \sum_{i=1}^{\rho} \alpha \Delta y_{t-1} + u_t \quad (1)$$

Where: Δy_t is the first difference of y_t; i.e., $y_t - y_{t-1}$ (y_t as the vector of the main endogenous in this study), $\phi = \alpha - 1$ and α is a coefficient of y_{t-1}

Phillips and Perron propose a nonparametric correction to the simple Dickey-Fuller test in order to solve the problem of autocorrelation and/or heteroscedasticity of errors. This time series is integrated in order 1; the series of differences is in fact stationary. This model is presented as follows:

$$\Delta y_t = \rho y_{t-1} + \beta_i C_{t-1} + \varepsilon_t \quad (2)$$

Where is a I(0) with an average of zero C_{t-1} is a deterministic trend component.

Cointegration

The tests of long-run relationships between investment represented by agricultural investment and agricultural growth assessed in terms of agricultural output are measured using the Johansen-Josseleus (1990) cointegration test. Being nonlinear, the variables are of the Cobb-Douglas model and are converted to a logarithm; therefore, the researcher came up with the following equation:

$$\text{lnAGROP} = \beta_0 + \beta_1 \text{lnAGRIV} + \beta_2 \text{lnLABFO} + \beta_3 \text{lnLANDU} + \beta_4 \text{lnEDUCA} + \varepsilon_t \quad (3)$$

Where:

LnAGROP = log of agricultural output measured in millions USD

LnAGRIV = log of agricultural investment measured in millions USD

LnEDUCA = log of education measured in percentage of schooling (15 years and above)

LnLANDU = log of land use in hectares

LnLABFO = log of labour force in percentage

$\beta_1 - \beta_5$ = coefficients determining the partial elasticities of explanatory variables.

ε_t = white noise

Error correction model (ECM)

The ECM is a model which determines short-term dynamism (expressed by the variables in first difference) and in the long term (expressed by the variables in level) by taking the relation between two variables.

$$Y_t = u + \beta_1 X_t + \varepsilon_t \quad (4)$$

By relying on the representation hypothesis of Engle and Granger (1987), the researcher determines a relationship between cointegration and the error correction model (ECM) by developing the equation (5).

Cointegration equation between Y_t, and X_t are:

$$\varepsilon_t = Y_t - u - \beta_1 X_t \quad (5)$$

The Error Correction Models for Y_t, and X_t are as follows:

$$\Delta Y_t = u_y + \alpha_y \varepsilon_{t-1} + \sum_{h=1}^{l} \alpha_{1h} \Delta y_{t-h} + \sum_{h=1}^{l} \beta_{1h} \Delta X_{t-h} + u_{Yt} \quad (6)$$

$$\Delta X_t = u_X + \alpha_X \varepsilon_{t-1} + \sum_{h=1}^{l} \alpha_{2h} \Delta y_{t-h} + \sum_{h=1}^{l} b_{2h} \Delta X_{t-h} + u_{Xt} \quad (7)$$

Where u_{Yt} and u_{Xt} are stationary white noise pursues for a number of lags l. The coefficient of ECM, which is expected to be negative, measures the speed of adjustment of u_{Yt} and u_{Xt}, respectively, through the long run equilibrium.

Granger causality test

Granger (1969) suggests a time series data-based approach in order to determine causality. Let Y and X be two cointegrated variables, where there can be one of the following three relationships: 1) X influences Y; 2) Y influences X; and 3) X and Y, hence one influences the other mutually. The first two relationships are unidirectional whereas the third relationship is bidirectional. The Granger causality test is presented in the following form:

$$\Delta Y_t = \sum_{i=1}^{n} \alpha_i \Delta y_{t-i} + \sum_{j=1}^{n} \beta_j \Delta X_{t-1} + u_{1t} \quad (8)$$

$$\Delta X_t = \sum_{i=1}^{n} \lambda_i \Delta X_{t-i} + \sum_{j=1}^{n} \delta_j \Delta Y_{t-1} + u_{2t} \quad (9)$$

Equation 8 indicates that the present value of ΔY is appended on the two values; first, to past values of itself and second to past values of ΔY. In addition, Equation 9 shows the connection of ΔX to the anterior values itself and of ΔY.

RESULTS AND DISCUSSION OF RESULTS

Unit root tests

Before developing the cointegration and Granger causality approaches, unit root tests seek to verify whether the time series are non-stationary and integrated variables of order 1, I(1). Thus, to check whether the variables are non-stationary and I (1), the Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test were used in this paper. The findings of the tests are reported in Table 1, as presented below.

Unit root test on agricultural output (AGROP), agricultural investment (AGRIV), labour force (LABFO), land use (LANDU) and education (EDUCA) as transformed series by considering logarithm, first difference and including level with intercept in the table above was

Table 1. Results of unit root tests

Variable	Augmented Dickey-Fuller				Phillips & Perron			
	level with intercept	order of integration	1^{st} difference with intercept	order of integration	level with intercept	order of integration	1st difference with intercept	order of integration
LAGROP	–0.0825*	I(0)	–4.8236***	I(0)	–0.4322	I(1)	–5.0653***	I(0)
LAGRIV	–1.5300	I(1)	–4.8236***	I(0)	–1.9080**	I(0)	–4.8449***	I(0)
LLABFO	–0.7273	I(1)	–2.9731**	I(0)	0.1980**	I(0)	–2.9888**	I(0)
LLANDU	–1.4758	I(1)	–4.8687***	I(0)	–1.8327	I(1)	–4.9003***	I(0)
LEDUCA	–1.3697	I(1)	–2.6620***	I(0)	–5.8897***	I(0)	–2.9924**	I(0)

***, ** and * are 1%, 5% and 10% significance level respectively.
Source: own calculation from E-Views 10.

used to assess whether the series for this paper are stationary or non-stationary, i.e., if they are integrated with order 1, I[1] or 0, I[0] using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP).

The ADF unit root tests showed that agricultural investment, labour force, land use and education and PP unit root tests for agricultural output and land use were not stationary at level. Moreover, unit root tests at first difference for ADF and PP indicated that the series are stationary at 99 percent confidence level. This reveals that agricultural output, agricultural investment, labour force, land use and education are integrated with order one [I(1)]. The results obtained from ADF and PP unit root tests suggest that there is possible long-term equilibrium in the group of the series applied, so the regression of one on the other could not be spurious.

Cointegration test

Unit root tests indicated that all series included in the agricultural output (AGROP) model are I (1). This means that the series are cointegrated. However, if left untreated, it may lead to spurious estimates. This was demonstrated by the test findings of the OLS model presented in Table 2. Long-term estimates were used to assess the long-term equilibrium relationship between the variables. OLS regression was applied using logarithm data in order to measure elasticity, the results of which are presented in Table 2 below.

Table 2. Long-run analysis

Independent variables	Coefficient [t-statistic]
Constant	25.30203 [0.833734]
LOG(AGRIV)	0.219372*** [4.335519]
LOG(LABFO)	0.445214*** [5.568811]
LOG(LANDU)	–0.834752 [–0.462747]
LOG(EDUCA)	0.427465** [2.440057]
No. of observations	40
R-squared	0.949687
Adjusted R-squared	0.942288
F-statistic	128.3545
Durbin-Watson stat	0.680365

***, ** and * are 1%, 5% and 10% significance level respectively.
Source: E-Views 10.

The table presents the long-term equilibrium relationships between the explanatory variables (agricultural output and agricultural investment) and the regressors (labour force, land use and education).

These results show that agricultural investment, labour force and education impact agricultural output positively and the relationship is statistically significant. A 1% increase in agricultural investment will result in a 0.219% increase in agricultural output. These results support the argument by Purohit and Reddy (1999), Gulati and Bathla (2002) and Golait and Lokare (2008) which posits that the policy implication of capital formation in Indian agriculture is closely linked to the ongoing economic reform programmes in the country. Education also has a positive relationship with agricultural output. This indicates that in the long run, improvements in education generate a positive impact on agricultural output. These findings are similar to a study conducted in Pakistan by Ashraf et al. (2019).

The coefficient of determination (R-squared) of 0.9496 suggests that approximately 94.96% of fluctuations in agricultural output are explained by the fluctuations of AGRGCF, LABFO, LABFO and EDUCA.

The high value of F-statistics (128.354) indicates that the model's explanatory variables have a significant impact on agricultural output. The hypothesis of no autocorrelation of the error term is rejected since at 0.68 the Durbin Watson test indicates that there is a possibility of negative correlation. This is because it is closer to zero than to two, which indicates that no autocorrelation can be confirmed.

The error correction model

The cointegration and error correction equation for agricultural output (AGROP), agricultural investment (AGRIV), education (EDUCA), labour force (LABFO) and land use (LANDU) is estimated and presented below in Table 3.

The results of the ECM short-run regression analysis appeared with the negative sign and were statistically less significant. The independent variables (AGROP) have positive signs and are statistically significant. The short-run coefficient suggests that current agricultural investment (ΔLAGRIV) has a statistically significant

Table 3. ECM regression results

Independent variables	Coefficient	[t-statistic]
Constant	–0.019552	[–0.976026]
ΔL(AGROP(-3))	0.537305**	[2.401052]
ΔL(AGRIV)	0.159567**	[2.798852]
ΔL(AGRIV(-1))	–0.056194	[–733034]
ΔL(AGRIV(-2))	–0.194548**	[–2.450800]
ΔL(LABFO(-1))	–0.893856	[–1.220292]
ΔL(LABFO(-2))	0.485979	[0.571382]
ΔL(LANDU)	–5.132725**	[–2.351908]
ΔL(EDUCA(-1))	8.286191	[3.371430]
ΔL(EDUCA(-2))	–5.132725	[–2.351908]
ECM(-1)	–1.120603**	[–2.651619]
R-squared	0.795644	
S.E. of regression	0.028149	
Log likelihood	98.78759	
F-statistic	1.784481	
Durbin-Watson statistic	2.409838	

***, **, * Respectively significant at 1%, 5% and 10% level
Source: E-Views 10.

positive impact on agricultural output (ΔLAGROP) in the short run. On the other hand, agricultural investment in the previous two and three period lags affected agricultural output negatively. These results are consistent with the "vintage effect", which states that old capital is less productive than new capital per monetary unit of expenditure (Gittleman et al., 2006: 307). Based on these results, the null hypothesis that there is no short-run relationship between agricultural investment and agricultural output in the Democratic Republic of Congo could not be accepted. Thus, investment in machines, infrastructure and other factors does spur agricultural output (Mogues et al., 2012).

Granger causality test

Having established the presence of a long-run relationship between agricultural investment and agricultural output, we proceeded to investigate whether agricultural output causes agricultural investment and vice versa. To determine the feedback relationship between these two variables, the Granger causality test was applied. The following null and alternate hypotheses were postulated:

H_0: Agricultural investment (AGRIV) does not Granger-cause agricultural output (AGROP).

H_a: Agricultural investment (AGRIV) Granger causes agricultural output (AGROP).

H_0: AGROP does not Granger-cause agricultural investment (AGRIV).

H_a: AGROP Granger causes agricultural investment (AGRIV).

The findings reveal the presence of unidirectional causality flowing from agricultural output to agricultural investment. The causal relationship was observed to be statistically significant at 5%. The results suggest that an increase in agricultural output leads to agricultural investment growth, holding other factors constant. These findings are supported by Asamoah and Alagidede (2020). Other causal relationships which emerged are unidirectional causality from labour force to agricultural investment, labour force to education and agricultural

Table 4. Pairwise Granger causality results with 2 lags

Null hypothesis	Obs.	F-stat	Results
ΔLAGRIV does not Granger-cause ΔLAGROP	37	0.27729	H_0 is not rejected
ΔLAGROP does not Granger-cause ΔLAGRIV		3.92597**	H_0 is rejected
ΔLLABFO does not Granger-cause ΔLAGRIV	37	4.54635**	H_0 is rejected
ΔLAGRIV does not Granger-cause ΔLLABFO		1.5859	H_0 is not rejected
ΔLLANDU does not Granger-cause ΔLAGRIV	37	0.92503**	H_0 is rejected
ΔLAGRIV does not Granger-cause ΔLLANDU		0.03710**	H_0 is rejected
ΔLLANDU does not Granger-cause ΔLLABFO	37	3.60078**	H_0 is rejected
ΔLLABFO does not Granger-cause ΔLLANDU		3.62589**	H_0 is rejected
ΔLEDUCA does not Granger-cause ΔLLABFO	37	1.30345	H_0 is not rejected
ΔLLABFO does not Granger-cause ΔLEDUCA		2.73546*	H_0 is rejected

***, **, * Respectively significant at 1%, 5% and 10% level.
Source: E-Views 10.

investment to land use and bi-directional causality between land use and labour force. Similar results were confirmed by Chisasa and Makina (2015).

The findings of the Granger causality test on the variables under study appear in Table 4 below.

SUMMARY AND CONCLUSION

The aim of this paper was to examine the relationship between agricultural investment and agricultural growth in the Democratic Republic of Congo using the Cobb-Douglas production function. Time series data for the period from 1980 to 2019 were used for this purpose. The trend analysis revealed almost similar slopes at certain points in time between agricultural investment and agricultural output. For the cointegration analysis, the results of the trace and Eigen statistics tests showed that one out of five equations and two out of five equations, respectively, are statistically significant at the 5% level for each test. Hence, the null hypothesis of no cointegration was rejected. The latter shows that all the variables in this study have long-term equilibrium effects between them. This study has demonstrated empirically that in the long-run, agricultural investment, labour force and education have a positive and statistically significant impact on agricultural output. However, land use was observed to have a negative effect on agricultural output in the Democratic Republic of Congo. In the long run, the relationship between agricultural investment and agricultural output was found to be positive and statistically significant. A 1% increase in agricultural investment will result in a 0.83% increase in agricultural output. Thus, the null hypothesis that there is no supported long-run link between agricultural investment and agricultural output in the Democratic Republic of Congo was rejected. The Error correction mechanism (ECM) was used to determine the short-term equilibrium, but also to estimate the speed of adjustment between gross capital investment and agricultural output. The results show that agricultural investment, labour force and education significantly increased the agricultural output in the Democratic Republic of Congo. However, land use was found to affect agricultural output negatively. Finally, and in line with the second hypothesis of the study, causality tests revealed that there is a unidirectional causal relationship flowing from agricultural output to agricultural investment. This suggests that as farmers achieve increased levels of agricultural output, they can increase investment in capital equipment from sales proceeds.

The paper concludes that agricultural investment has a high and statistically significant influence on the increase in agricultural output, holding other factors constant. Based on the empirical results reported in this paper, it is recommended that government and private sector policies that stimulate agricultural capital investment be put in place in order to spur agricultural output and avert food insecurity in the Democratic Republic of Congo.

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