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Effect of Crude Oil Price on Agricultural Productivity in Nigeria (1981-2010)

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Abstract

This study examined the effects of crude oil price on agricultural productivity in Nigeria between 1981 and 2010. Agricultural productivity (proxy as agricultural GDP) was specified as a function of factors such as exchange rate, crude oil price, capital stock, labour, land and fertilizer. Quantitative estimates, based on Augmented-Dickey Fuller (ADF) unit root test, Co-integration and Error Correction modelling, indicate that the exchange rate, capital, labour and trend are the major determinants of agricultural productivity in the long-run, while price of crude oil price is the most important determinant of agricultural productivity in the short–run. The results further show that the error correction mechanism (ECM) indicated a feedback of about 112.5% of the previous year's disequilibrium from long-run domestic agricultural production.

Keywords: Agricultural productivity, crude oil price, error correction, co-integration.

Introduction

The petroleum industry in Nigeria has brought unprecedented changes to the Nigerian economy, particularly in the past five decades when it replaced agriculture as the cornerstone of the Nigerian economy. The oil industry has risen to the commanding heights of the Nigerian economy, contributing the lion share to gross domestic product and accounting for the bulk of federal government revenue and foreign exchange earnings since early 1970s. However, Nigeria's considerable endowment in fossil fuel has not translated into an enviable economic performance; rather, the nation's mono-cultural economy has assumed a precarious dimension in the past decades susceptible to the vagaries of the international oil market (Aigbedion and Iyayi, 2007).

The run-up in crude oil prices was motivated initially by demand-driven tightening of market balances; but later has been further fuelled by a combination of supply concerns and financial factors. Market tightening is expected to persist because of a sluggish supply response. Beginning from the last quarter of 2008, demand pressures have eased as global output growth slowed down, owing largely to the global economic and financial crises. Oil prices are likely to remain volatile, arising from low stocks, limited spare capacity, supply disruptions, and uncertainty over exploiting new reserves and the development of non-oil sources (Egwaikhide, 2012).

As a net seller of crude oil, many Nigerians today strongly believe that the nation should be free from any negative oil price shocks. However, the reality is a far cry from this expectation. Only few households seem to benefit from the oil windfall while others are subjected to further deprivation, higher food prices, higher transport costs and higher energy costs. On the other hand, there are groups of analysts who believe that the massive infrastructural development of the mid-1970s would not have been possible if not for the oil money. So much so that the debate about the economic impact of the oil windfall has now become the concern of all and no more the exclusive preserve of economists (Egwaikhide, 2012).

The challenge of resuscitating agricultural production and development in Nigeria is an enormous one. This is because of the dramatic shift in the fortunes of the sector over the years; from the dominant sector of the economy (contributed 64.1 percent to GDP) and supplier of food, income, foreign exchange and employment in the 1960s to a net importer of food contributing less than 5 percent to total foreign exchange earnings in 2000. Many policy analysts attribute this to the sector's neglect following the discovery of petroleum resources beginning from the early 1970s and the accompanying foreign exchange fortunes. Farming was not only abandoned, the structure of domestic demand for food and agricultural products was altered in favour of imports of grains, beverages and vegetable oils and fibres which Nigeria was once reputed as a leading world producer (Oyekunle, 2013).

The task of resuscitating agricultural production for domestic use and exports is therefore very daunting. This would require finding solutions to the negative effects that fluctuations in oil prices have impacted on agriculture in the country. Also, it would require stepping up production to meet and bridge the import gap, provide for strategic food reserves and generate surplus for exports to earn income and sustain farming enterprise in general. It goes beyond resuscitation of traditional exports to conscious efforts at developing and promoting new commodities for exports.

The overall objective of this study was to empirically assess the effects of crude oil price on agricultural productivity in Nigeria between 1981 and 2010 using a dynamic regression model. Specifically, co-integration and error correction model (ECM) was followed to give policy recommendations.

Conceptual framework and theoretical issues

In Nigeria, evidences exist regarding resource management and outcomes (Adebipe, 2004; Odularu, 2008; Van, 2008; Akpan, 2009). Adepibe (2004) focused on the impact of oil on Nigeria's economic policy formulation from 1960 to 2000. Detailed descriptive analysis was explored. From the historical evaluation of economic policies, it was evident that prior to the discovery and extraction of oil in commercial quantities, agriculture was the mainstay of the Nigerian economy. However, with the advent of oil, unprecedented wealth accrued to the Nigerian government, which subsequently affected policy formulation. There were series of policy reversals which took their toll on the real sector of the economy; leading to its neglect. The findings of Odularu (2008), who analysed the relationship between the crude oil sector and Nigeria's economic performance, were similar to those of Adebipe (2004). Using Ordinary Least Square (OLS) regression method for the period 1970 to 2005, the findings revealed that crude oil consumption and exports had contributed positively to the improvement of the Nigerian economy. A striking issue emerging from the results is the finding that, despite the positive relationship between domestic consumption and export of crude oil, the coefficient of crude oil export was insignificant. Plausible reasons advanced by the author were misappropriation of public funds (corruption) and poor administration. The author recommended the need for urgency in diversifying the export market, especially the oil market, fight corruption and the encouragement of private sector participation in crude oil activities. A flaw observed in the analysis is the absence of some diagnostic tests on the specification to ascertain the appropriateness of the specification. Similarly, unit root tests were not conducted on the series to determine their stationarity or otherwise. In econometric analysis involving time series, this is crucial to avoid spurious regressions (Engle and Granger, 1987).

Using a VAR methodology, Akpan (2009) investigated oil price shocks and Nigeria's macro economy for the period 1970 to 2007. The study pointed out the asymmetric effects of oil price shocks. For instance, positive as well as negative oil price shocks significantly increased inflation and also directly increased real national income through higher export earnings, though part of this gain was seen to be offset by losses from lower demand for exports, generally due to the economic recession suffered by trading partners. The findings of the work further showed a strong positive relationship between positive oil price changes and real government expenditures. Unexpectedly, the result identified a marginal impact of oil price fluctuations on industrial output growth. Furthermore, the "Dutch Disease" syndrome was observed through significant real effective exchange rate appreciation. The result confirmed the neglect of the agricultural sector following the advent of oil, as observed in previous works (Adepibe, 2004; Odularu, 2008).

Methodology

Analytical technique: Error correction and co-integration model

This study adopted the Johansen (1988) procedure in co-integration. The concept of co-integration (Hendry, 1986; Hall, 1986; Mills, 1990), creates the link between integrated process and the concept of steady equilibrium. The first step in co-integration analysis is to test the order integration of the variables. According to Ajetomobi *et al.* (2006), a series is said to be integrated if it accumulated some past effects, so that following any disturbance, the series will rarely return to any particular mean value, hence is non-stationary. Non-stationary time series has always been regarded as a problem in econometric analysis. Philip (1986) showed that, in general, the statistical properties of regression analysis using non-time series are dubious, notwithstanding promising diagnostic test statistics from such regression analysis. The order of integration is given by the number of times a series needs to be differenced so as to make it stationary. According to Charemza and Deadman (1992), a stochastic process is said to be stationary if the joint and conditional probability distributions of the processes are unchanged if displaced in time. If the series are co-integrated of the same order, a linear relationship between these variables can be estimated, and examining the order of this linear relationship can test for co-integration. The grim fact is that economists look for the presence of stationary co-integrated relationships, since only these can be used to describe long-run stable equilibrium. The Granger representation theorem states that if set variables are co-integrated (1, 1); implying that the residual is co-integrated of 1(0), then there exists an error correction model describing the relationship.

Model Specification

Drawing from Hemphill (1974), Moran (1987), Udoh *et al.* (2001), Nkang *et al.* (2006) and Binuomote *et al.* (2010), the hypothesized structural relationship for agricultural gross domestic product will be specified as follows:

$$LAGDP = \beta_0 + \beta_1 LEX + \beta_2 LP_o + \beta_3 LK + \beta_4 LLb + \beta_5 LLd + \beta_6 LF + T + \mu \quad (1)$$

Where *LAGDP* is the agricultural gross domestic product; *LEX* is the exchange rate; LP_o is the price of crude oil; *LK* is the invested capital, *LLb* is the quantity of labour, *LLd* is the size of land, and *LF* is the amount of fertilizer. The estimated linear function of the above specification was found to give the lead equation, on which the discussions were made.

The error correction model

First, the variables in equation (1) were tested for unit root using the ADF technique while Johansen (1988) reduced-rank test for co-integration was used to test for co-integrations relationship between selected sets of variables at crop level data. The error correction model (ECMs) estimates are shown in (2) below. ECM in (2) represents the short run behaviour of agricultural gross domestic product in (2) while equation (1) represents the long run static equations. The parameter λ, which is negative, in general measures the speed of adjustment towards the long run equilibrium relationship between the variables in (2). The optimum lag lengths to be included in equations (2) were determined based on Akaike Information Criterion (AIC).

Static long run model for agricultural gross domestic product

$$LAGDP = \beta_1 + \beta_2 LEX + \beta_3 LP_o + \beta_4 LK + \beta_5 LLb + \beta_6 LLd + \beta_7 LF + T + \mu \quad (1)$$

Error correction model (ECM) for the agricultural gross domestic product model is also given as equation (2)

$$\Delta LAGDP = \gamma_0 + \sum_{i=1}^{p} \gamma_1 \Delta LEX_{t-p} + \sum_{i=1}^{j} \gamma_2 \Delta LPo_{t-j} + \sum_{i=1}^{k} \gamma_3 \Delta LK_{t-k} + \sum_{i=1}^{m} \gamma_4 \Delta LLb_{t-m} + \sum_{i=1}^{y} \gamma_5 \Delta LLd_{t-y} + \sum_{i=1}^{z} \gamma_6 \Delta LF_{t-z} + \mu_t ECM \quad (2)$$

where Δ represents first differencing, λ measures the extent of correction of errors by adjusting in independent variable, *β* measures the long-run elasticity while γ measures the short-run elasticity. General-to-specific modelling technique of Hendry and Erricson (1991) was followed in selecting the preferred ECM. This procedure first estimates the ECM with different lag lengths for the difference terms and, then, simplify the representation by eliminating the lags with insignificant parameters.

Data and data sources

The data for this study are time series data at the macro level spanning from 1981 to 2010. The data were largely sourced from Food and Agricultural Organization (FAO) statistical data base for United Nations, Penn world data of the University of Pennsylvania and Central Bank of Nigeria (CBN) statistical bulletin (2006 edition). The data include agricultural gross domestic product, exchange rate, crude oil price, capital, labour, land and fertilizer.

Test for stationarity

The results of the unit root tests are shown in Table 1. The null hypothesis of the presence of a unit root (non-stationarity) was tested against the alternative hypothesis of the absence of a unit root (stationarity). All the tested variables contain unit root processes, and all except two (land and fertilizer), became stationary after first difference. Hence, the variables were integrated of order 1 and 2; that is I (1) and I (2). This established the suitability of the variables with order I (1) for use in co-integration.

Results and discussion

Table 1: ADF Unit Root Test Results for Selected Variables (Constant and Trend Included)

Critical vales: 5% = -3.594 1% = -4.355s

Variables	t-values (level)	t-values (1^{st} difference)	Order of Integration
LAGDP	-3.1242	-7.8582**	1
LEX	-2.5234	-4.0788*	1
LP_O	-4.2824	-8.0315**	1
LK	-1.0379	-4.7862**	1
LLb	-1.0759	-4.7760**	1
LLd	-1.4157	-3.2648	2
LF	-0.91062	-3.5392	2

Source: Data Analysis, 2012. ***, ** and * indicates significant at 1%, 5%, and 10%

Test for Co-integration

Table 2 shows the Johansen test for evidence of co-integration relationship among selected variables. On application of the test, the results of the maximum-Eigen value statistics and trace statistics from Table 2 show that, there is at least 1 co-integration relation. This indicates that there exists a long-run relationship between all the explanatory variables and the explained variable. Since co-integration has been established, the regression results were analysed and diagnosed.

Table 2: Results of the Johansen's maximum Eigen-value and Trace statistic co-integration test

$H_0 : \rho$	Maximum Eigen-value	Trace Statistics
ρ = = 0	88.88**	145.1**
ρ < = 1	25.1	56.23
ρ < = 2	18.25	31.13
ρ < = 3	8.34	12.88

Source: Data analysis, 2012

Short-run error correction results and diagnostics

The solved static long- run equation for agricultural productivity in Nigeria as well as its short – run equation are given in Table 3. The R^2 value of 0.720 for the ECM in Table 3 shows that the overall goodness of fit of the ECM is satisfactory. This means that only 72% of the variation in agricultural gross domestic product is explained by the explanatory variables; the remaining 28% is inherent in error term or white noise. However, a number of other diagnoses were also carried out in order to test the validity of the estimates and their suitability for policy discussion. The Autoregressive Conditional Hetoroscedasticity (ARCH) test for testing heterscedasticity in the error process in the model had an F-statistic of 0.556, which is statistically insignificant. This attests to the absence of heteroscedasticity in the model. The Jacque- Bera χ^2 - statistic of 2.92 for the normality in the distribution in the error process shows that the error process is normally distributed. From the battery of diagnostic tests presented and discussed above, this study concludes that the model is well estimated and that the observed data fit the model specification adequately; thus the residuals are expected to be distributed as white noise and the coefficient valid for policy discussions.

It could be observed from the results in Table 3 that the coefficient of error correction term (ECM) carries the expected negative sign and it is significant at 1%. The significance of the ECM supports co-integration and suggests the existence of long-run steady equilibrium between agricultural gross domestic product and other determining factors in the specified model. The coefficient of -1.125 indicates that the deviation of agricultural gross domestic product (AGDP) from the long-run equilibrium level is corrected by 112.5% in the current period.

The short-run coefficient of agricultural gross domestic product $(LAGDP)$ in the immediate past period is 0.214. This result is positive and it could be due to increase in farmers' output of crops along with improved producer price. This will probably have a positive impact on agricultural productivity in the current year.

The exchange rate (LEX) has a positive coefficient of 0.066 and 0.076 in the long and short-run respectively which are both significant at 5%. However, the short-run coefficient of exchange rate in the immediate past period was -0.06 and significant at 10%. This means that there has been an improvement in the devaluation of the currency in the current year. The elasticity values of exchange rate in both the short and long-run suggests that devaluation will decrease import of agricultural crops, thereby encouraging local production which will subsequently increase agricultural productivity.

In the short-run, crude oil price (LP_O) has a negative and significant coefficient of 0.04. However, in long-run, it has a negative but insignificant coefficient of 0.034. The elasticity value obtained for crude oil price in the short-run is in line with theoretical expectation, since it is expected that as the world price of crude oil increase, the focus on agricultural productivity will further shift away. Also, the rapid rise in crude oil prices exerted an upwards pressure on food prices; as fertilizer prices nearly tripled and transport costs doubled over a two year period. At one time, agriculture contributed the larger percentage to the nation's economy but the advent of crude oil exploration has contributed to the neglect of the agricultural sector. The results are in perfect agreement with the belief that, the advent of crude oil has affected the Nigerian agricultural sector negatively and significantly.

The coefficient of capital (LK) is significant only in the long-run with a value of 73.071 at 5% level. However, it had a negative insignificant coefficient in the immediate past period; which means there has been an increased investment in the agricultural sector in the current period. It also has a positive but insignificant coefficient in the short run. This results means that a unit increase in capital investment in agriculture has the capacity to increase agricultural productivity, positively and significantly in the long run by 73. 071 units

In the long-run, labour (LLb) has a negative coefficient of -18.032 which is significant at 5%. However, in the short run; it has a negative insignificant coefficient. This result means that a unit increase in labour will result in 18.032 units decrease in agricultural productivity. This is probably because of the migration of the rural farming population to the urban areas because agriculture is predominantly practiced in the rural areas. Labour is usually measured in man-days, especially in developing countries like Nigeria.

Time trend (T) , which represents technology, was modelled into the series as represented by the time variable serving as proxy for the impact of technology change on productivity. It has a coefficient of 0.049 and it is significant at 5%. This result further justifies that capital and price factors are not sufficient to increase agricultural productivity in Nigeria; it takes a good combination of labour and structural factors, one of which is technology.

Table 3: Static long-run and Short-run error correction model estimate results.

Static Long-run equation		***Parsimonious Short-run equation***	
Constant	3988.5(2.356)	Constant	0.115(3.046)
LEX	0.066 (2.673)**	Δ LAGDP(-1)	0.214(1.091)
LP_o	-0.034(-1.100)	ΔLEX	0.076(2.811)**
LK	7.307(2.437)**	ΔLEX(-1)	-0.06(-1.988)*
LLb	-18.032(-2.376)**	ΔLP_o	-0.04(-1.694)*
Trend	0.049(2.043)**	$\Delta LP_o(-1)$	-0.001(0.041)
		ΔLK	45.34(0.737)
		ΔLK(-1)	-0.780(-0.640)
		ΔLLb	-1173.1(-0.772)
		ECM(-1)	-1.125(-4.449)***
		$R^2 = 0.720$	
		AR F(2,14)	= 1.815 (0.199)
		ARCH F(1,14)	= 0.556 (0.468)
		Normality χ^2	= 2.92 (0.232)

Source: Data Analysis, 2012. ***, ** and * indicates significant at 1%, 5%, and 10%
ECM = LAGDP -3988.5 – 0.066LEX + 0.034LP_o $^-$ 73.071LK + 1803.2LLb;

Conclusion and Policy Recommendations

This study shows that crude oil price actually has a negative and significant effect on agricultural production in Nigeria. However, agricultural production in Nigeria can be increased by diversifying the economy; shifting focus away from the export of crude oil only and concentrating more on the local production of agricultural produce and the export of its surplus. The agricultural population, predominantly resident in the rural areas, should be provided with basic social amenities and inputs at subsidized rates. The private sector along with the government should work together by investing in the agricultural sector, especially in the areas of provision of modern production and processing technologies. These technologies, if they aresupplied, will significantly increase agricultural production and contribute largely to the nation's gross domestic product.

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