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Optimizing agricultural value chain in Nigeria through infrastructural development

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Abstract The paper investigates the impact of infrastructural development on agricultural value chain in Nigeria and finds that infrastructural development has a significant positive impact on the agricultural value chain in the long as well as short run. The macroeconomic instability, on the other hand, exerts the opposite impact. A comprehensive policy framework is required to enhance agricultural value chain output and promote investment in human and physical capital while carefully managing macroeconomic instability and distortions. Governments at all levels should prioritize infrastructural development to optimize the benefits from the agricultural value chain.

Keywords Agricultural value chain, ordinary least squares (OLS), dynamic OLS, fully modified OLS, infrastructural development, Nigeria

JEL codes H54, O13, Q18

The role of infrastructure in economic growth and development is well documented; infrastructural development is pivotal to growth and, by extension, to the agricultural value chain. Agricultural value chains connect urban consumption and rural production and impact marketing and production systems (Mango et al. 2015). The agricultural value chain is critical in Nigeria, particularly for rural farmers who seek to extract more local value from agricultural products. The quest for increasing added value is underpinned on its advantages—higher incomes, increased employment, and investment opportunities. Any improvement in the agricultural value chain is directly related to the growth in the agricultural value added. This is relevant given the empirical finding that the multiplier effect of growth in agriculture is higher than in other sectors (de Janvry and Sadoulet 2010). An increase in value chains can bring about a concomitant rise in job opportunities, and Nigeria can gain in the number and size of modern value chains. It is known, for instance, that in the more developed and urbanized countries, the industries and services linked to agricultural value chains account for over 30% of GDP (World Bank 2007).

A key feature of modern agricultural value chains is that they usually offer wage and self-employment with pay and work conditions better than in traditional agriculture. This is important to women, who tend to dominate small-scale or household farming in many developing countries. Given the role that value chains can play in the reduction of gender income disparity, a deliberate effort at improving the agricultural value chain in Nigeria will help deal frontally with the issues of gender inequality and living standards for many households. The issue has global importance as well, as women constitute 20–30% of agricultural wage workers worldwide, and this figure is higher in some Latin American and African countries (Hurst, Termine, and Karl 2007).

Agriculture has a relatively large share in employment, and this share underscores the significance of agricultural value chains in developing countries, as growth in the agricultural sector can help address development constraints relating to distributional issues and poverty reduction (Delgado et al. 1998). This is critical for Nigeria, as its economy is dependent largely on the production and export of crude oil and natural gas for foreign exchange. The country enjoys a relatively high growth in income due to the high value of oil and gas output, but the per capita income is low, because its population is large. Developing the agricultural value chain is key in the efforts at economic diversification and associated benefits.

Past studies focused primarily on the link between agricultural output/growth and infrastructural expenditure in Nigeria. The link between agricultural value chain and infrastructure has not been given much attention. How are infrastructure and the agricultural value chain related? What is the impact of infrastructure on the agricultural value chain? How can infrastructural development optimize the agricultural value chain? By seeking to answer these questions, this study fills the research gap and underscores the imperatives of infrastructural development in optimizing the agricultural value chain in Nigeria.

Conceptual framework

In the economic literature, infrastructure is a multi-dimensional concept, encompassing services that range from transport to clean water. Infrastructure can be measured in terms of its contribution and requirement (physical and social) to society (Buhr 2003). Value chains represent enterprises in which producers and marketing companies work within their respective businesses to pursue one or more end markets. A value chain comprises the entire range of efforts undertaken to bring products from the initial input-supply stage, through various phases of processing, to its final market destination, and it includes its disposal after use (UNIDO 2009). An agricultural value chain identifies the set of actors and activities that bring an identified or basic agricultural product from production to final consumption, where value is added to the product at each stage (FAO 2005), and it encompasses all value-generating activity, sequential or otherwise essential to the production, delivery, and disposal of a commodity (Schmitz 2005).

One method adopted in the literature to determine the impact of infrastructure on economic growth is the growth model approach, classified into the neoclassical framework (Solow 1956; Swan 1956) and endogenous growth models (Lucas 1988; Barro 1990; Grossman and Helpman 1991; Aghion and Howitt 1992). In the endogenous growth models, both public and private capital stock accumulation are included in the production process to show the effect of public investment in infrastructure on growth. Another important way that infrastructure can be used to analyse an agricultural value chain is the cost function, in which it is assumed that infrastructure investment is provided externally by the government as a free input in the production process. The growth model approach is adopted in this study.

The literature linking infrastructure to agricultural output and productivity provides a rich resource for the examination of the impact of infrastructure on agricultural value chain, since they are by nature production- or output-related activities. Generally, productivity increase in agriculture and, by extension, in agricultural value chains depends on good rural infrastructure, well-functioning domestic markets, appropriate institutions, and access to appropriate technology (Andersen and Shimokawa 2007). The empirical literature finds that infrastructural deficiencies impact development negatively; poor investment in infrastructure, or the lack of investment, constrains growth. Causation is found to run from infrastructure to economic growth; any regional infrastructural imbalance negatively impacts the prospects of a region's economic growth (Llanto 2007), and infrastructure could be a vital variable in regional convergence (Cuenca 2004). Fan, Jitsuchon, and Methakunnavut (2004) find that public investments in infrastructure (including roads and electricity), agricultural research and development, irrigation, and rural education positively impact growth in agricultural productivity. Infrastructure impacts productivity in several ways; for example, efficient transportation infrastructure reduces the costs of labour market participation, thereby eliminating a key obstacle to market entry for labour.

Good physical infrastructure reduces the cost of food for urban dwellers and promotes skills transfer from rural to urban centres. When roads are readily accessible, consumption rises as much as 16% and the incidence of poverty falls by 6.7% (Dercon et al. 2009). A study on the Greek economy by Mamatzakis (2005) indicates that public infrastructure lowers the total cost of agriculture; on the Philippines, Evenson and Quizon (1991) find that roads have a significant positive impact on inputs, outputs, and net profits, while on Philippine agriculture, Teruel and Kuroda (2004) find that public infrastructure fuelled the high productivity growth during the period from 1974 to 1980.

Increasing capital stocks in agricultural productivity is a challenge (FAO 2009), and investments in rural public goods improve agricultural productivity and, thus, reduce poverty (FAO 2012 a). Infrastructure and road development are considered the top drivers of overall economic growth in rural areas (Mogues 2011), but the inadequacy of capital is a serious problem in developing countries. In Latin America, 65% of adults lack access to formal financial institutions; the corresponding figure is 80% in sub-Saharan Africa and 58% in South Asia and East Asia (Chaia et al. 2009). At the country level, less than 1% of farmers in Zambia and less than 2% in rural Nigeria have access to formal credit (Meyer 2011).

Inflation can be used to measure the extent of macroeconomic instability, and it has been cited in studies of agriculture and the agricultural value chain, because dealing with inflation provides an enabling environment not only for agriculture and agricultural value chain but for investments across sectors (FAO 2012 a). The study showed also that taxing agriculture relative to other sectors reduces national economic welfare and overall output growth over time.

Materials and methods

This study uses annual time series data from 1991 to 2016, the period for which data on the relevant variables is available. We obtained the data from FAOSTAT, International Labour Organization (ILO), and the Central Bank of Nigeria (2016). The theoretical framework for the study is a synthesis of the production function and growth approaches, consistent with Barro (1990). The agricultural value chain (output) is expressed as

$$Y_t = f(K_t, L_t, \Pi_t, \sigma)$$

where at time t, Y is the output of agricultural value chain, K is capital stock, L is labour, Π is the infrastructure variable, and σ is a control variable. In econometric form, the model estimated in this study is

$$Avco = \beta_0 + \beta_1 Cap_t + \beta_2 Lab + \beta_3 Infradev_t + \beta_4 Inf_t + \varepsilon_t$$

where Avco is agricultural value chain output, Cap is capital, Lab is labour, Infradev is infrastructural development, Inf is inflation, and ε is the stochastic error term.

Infrastructure is expected to have a significant positive impact on the agricultural value chain. Our measure of agricultural value chain output (Avco) is on oil palm, conceptualized as a chain involving production, processing, and distribution. For simplicity, we considered production and processing, encompassing oil palm fruit production, oil palm processing, and oil palm kernel processing. Each stage is conceptualized to have its output value in the chain.

We added the three segments in the value chain to derive the total output; the total output in the value chain (in metric tons) is a summation of each value in, respectively, palm fruit production, oil palm processing, and oil palm kernel processing. This aggregation is in line with the definition of value chain offered by Kaplinksy and Morris (2002), which 'describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformations and the input of various producer services), to delivery to the final consumer and final disposal after use.' Our aggregation is limited to production and processing, however, because of the paucity of data. We measured capital using gross fixed capital formation in agriculture, forestry, and fishing. Our measure of labour is employment in agriculture, while rail lines (total route kilometres) was used to measure infrastructural development. Inflation was taken as a measure of macroeconomic instability and used as a control variable.

To estimate Equation 2, we investigated the stochastic properties of the variables using three unit root tests: Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS). All three traditional unit roots were deployed to examine their consistency. The PP unit root test is considered to be more reliable than the ADF because it is robust in the midst of serial correlation and heteroscedasticity (Hamilton 1994). The ADF and PP tests suffer from low power and high size distortion (Zivot and Andrews 1992), and so we included the KPSS test to avoid these problems. To perform the unit root test for a variable such as X we use the specification

$$\Delta X_t = \phi_0 + \phi_{1t} + \phi_2 X_{t-1} + \sum_{i=0}^{p} \pi_i \Delta X_{t-i} + \varepsilon_t$$

where, ϕ_0, ϕ_1, ϕ_2 and π_1,..π_p are parameters to be estimated, and ε_t is the Gaussian white noise disturbance term.

The Johansen (1988, 1991) cointegration test follows the unit root tests, after which if a long-run relationship is found among the variables, the cointegrating equation is examined. Two approaches were followed in this study. First the ordinary least squares (OLS) method was used to generate the cointegrating regression, including the error correction model, in line with established practice. We followed Hendry's (1986) general-to-specific methodology to achieve parsimony in the error correction model. The post-estimation diagnostics in the OLS regression include tests for autocorrelation, normality, heteroscedasticity, and specification bias.

However, it is known that OLS in cointegrating equations is fraught with the problem of non-normal distribution, invalidating the results of statistical inferences; to surmount this problem, it is imperative to use the appropriate estimators. We adopted the dynamic OLS (DOLS) estimator, pioneered by Stock and Watson (1993), and the fully modified OLS (FMOLS), originally developed by Phillips and Hansen (1990). The advantage of the DOLS approach is that it introduces dynamics in the specified model while accounting for simultaneity bias. The DOLS estimator of the cointegrating regression equation incorporates all variables in levels, including leads and lags of the change in the regressors, using the specification

$$Y_t = \delta_0 + \delta_i X_t + \sum_{j=-p}^{p} \Gamma_i \Delta X_{t-j} + \mu_t$$

where Y_t is the regressand, X_t is a vector of regressors, and Δ is the lag operator.

We estimated the DOLS model using the Newey–West heteroscedastic and autocorrelation consistent covariance matrix estimator, with robust standard errors, thus validating the inferences about the coefficients of the variables entering the regressors in levels and solving the problem associated with non-normal distribution of the standard errors of the cointegrating regression equation. We utilized 0 lead and 1 lag of the change in the regressors, with the lag selection based on the Schwarz–Bayesian information criteria. The advantage of using the FMOLS framework is that it modifies least squares and accounts for serial correlation effects and for the endogeneity in the regressors, thus providing optimal estimates of the cointegrating regressions.

The Toda–Yamamoto (1995) causality test is based on an augmented vector autoregression (VAR) model, with a modified Wald test statistic; the advantage of this approach to causality is that the initial test for cointegration need not be implemented. In comparison to the conventional Granger causality, the Toda–Yamamoto framework possesses a higher power for series that exhibit different levels of integration and enhances the chances of avoiding spurious regression and having a correct specification.

The Toda–Yamamoto approach involves three steps. First, the conventional ADF unit root test is used to determine the maximum order of integration in the model. Next, based on a selection criterion, a well behaved optimal lag order VAR model is implemented in levels (in terms of autoregressive (AR) unit root graph or roots of characteristic polynomial, VAR serial correlation, and residual normality tests). Finally, the modified Wald test is executed by deliberately over-fitting the underlying model with extra lags. We employed the Toda–Yamamoto test to investigate the causal link between agricultural value chain output and associated explanatory variables, and we implemented all the estimations in Eviews 10.

Results and discussion

Appendix 1 presents the descriptive statistics of the variables used in the study. The correlation matrix indicates that the agricultural value chain output has a statistically positive relationship with gross fixed capital and infrastructure (rail lines) and a statistically negative relationship with inflation. The relationship between agricultural value chain output and employment is negative but not statistically significant. The multicollinearity among the explanatory variables is not high, the highest correlation coefficient being 0.83 between capital and labour.

The unit root test results with intercept (Table 1 A) and an intercept and linear trend (Table 1B) are

Table 1 Unit root test results

Table 1A Unit root test results (with intercept)

Variable	ADF		PP		KPSS	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
Avco	–2.485	–3.085**	–2.439	–3.053**	0.418***	0.724
Cap	–0.479	–3.948*	–0.525	–3.901*	0.886*	0.183
Lab	0.286	–3.511**	0.038	–3.512**	0.747*	0.243
Infradev	–2.104	–5.829*	–3.214**	–15.523	0.487**	0.049
Inf	–2.011	–4.899*	–2.179	–4.959**	0.417***	0.073

Table 1B Unit root test results (with intercept and a linear trend)

Variable	ADF		PP		KPSS	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
Avco	–0.553	–5.323*	–0.307	–5.343**	0.240*	0.054
Cap	–1.815	–3.829**	–1.969	–3.769**	0.133***	0.182
Lab	–1.563	–3.581***	–1.657	–3.576***	0.213**	0.076
Infradev	–2.429	–6.353**	–4.946*	–10.873	0.138***	0.078
Inf	–2.579	–4.790*	–2.843	–4.894*	0.174**	0.074

Note *,** and *** denote rejection of the null hypothesis at 1%, 5% and 10% level of significance respectively. The null hypothesis is that the variable (in series) is non”stationary for ADF and PP. For KPSS, the null hypothesis is that the variable is stationary.
Source Authors' computations.

consistent for all three frameworks, and the results suggest that *Avco, Cap, Lab, Infradev,* and *Inf* are stationary in first difference; the only point of departure is the PP test with respect to RL which tends to be stationary in level. However, when contrasted with the KPSS results, the null hypothesis—the variable is stationary—is rejected. To obviate spurious regression, a test of cointegration was implemented; if the null hypothesis of no cointegration is rejected, the variables in their level form become appropriate for estimation. The cointegration test results suggest that there is cointegration (a long-run equilibrium relationship) among the variables, as the maximal eigenvalues and trace test statistics show that the hypothesis of no cointegration is rejected at the 5% significance level (Table 2). There are two cointegrating vectors based on the trace test statistics and one cointegrating vector in the maximal eigenvalues statistics. We estimate the specified model using the variables in levels following the existence of long-term equilibrium relationships

Table 2 Johansen cointegration test results

Hypothesis		Eigen value	λ_{max}	5% critical value	λ_{trace}	5% critical value
Null	Alternative					
r = 0	r ≥ 1	0.803	37.309*	33.877	85.347*	69.819
r ≤ 1	r ≥ 2	0.587	20.360	27.584	48.038*	47.856
r ≤ 2	r ≥ 3	0.499	15.877	21.132	27.677	29.797
r ≤ 3	r ≥ 4	0.243	6.407	14.265	11.800	15.494
r ≤ 4	r ≥ 5	0.209	5.393	3.841	5.393	3.841

Note r indicates the number of cointegrating vectors. * indicates rejection of the null hypothesis at 5% level of significance.
Source Authors' computations.

among non-stationary variables, thereby precluding the incidence of spurious regression (Table 3).

Long-run estimates

The coefficient of capital *(cap)* is directly related to value chain output, and it is statistically significant at 1% for the OLS and DOLS frameworks and at 5% for the FMOLS, implying that greater capital accumulation is associated with greater agricultural output along the value chain. Given the improvement in the country's fixed capital formation, the agricultural value chain can be improved. The result is consistent with the call to increase capital stock in agricultural productivity (FAO 2009), given its seriousness in developing countries (Chaia et al. 2009; Meyer 2011) and particularly in the rural areas (Pinstrup-Anderson and Shimokawa 2006).

The labour coefficients indicate a statistically significant positive relationship with the agricultural value chain output, because higher levels of labour input (employment) imply higher levels of output in the agricultural value chain. Thus, each chain in the agricultural set-up requires skills that will translate the output into value. The results are consistent with the literature, which considers employment critical to growth; and the implication is that the presence of a greater percentage of the labour force in the agricultural value chain will on one hand reduce the colossal waste in Nigeria's manpower resources and the welfare loss due to lower output and, thereby, improve total output, income, and well-being. This is important in that unemployment is a serious issue in developing countries (Rama 1998) and particularly in Nigeria (Umo 1996).

The coefficients of infrastructural development *(infradev)* are positively associated with agricultural value chain output, and the coefficients are statistically significant at the conventional levels across the regression frameworks, implying that infrastructural development promotes the value chain. This is in line with the empirical findings that link improvements in infrastructure to increases in agricultural output (Tran and Kajisa 2002; Barrett et al. 1999; Gabre-Madhin and Haggblade 2004; Mogues 2011). The result is consistent with the literature linking infrastructure to increased economic growth (Stiglitz and Charlton 2006). Infrastructural development lowers production cost, raises efficiency and productivity, and stimulates foreign investment (Wheeler and Mody 1992). Infrastructural development can improve access to new markets and stimulate exports, and the empirical literature stresses its role in increasing economic growth (Canning and Bennathan 2000).

Inflation lowers purchasing power and the standard of living, and it demonstrates the degree of macroeconomic instability. The estimated coefficients of inflation are statistically significant, except in the DOLS; thus, inflation is negatively related to the agricultural value chain output, and macroeconomic instability harms the agricultural value chain. Inflation imposes serious constraints on economic agents in the value chain in an environment of high costs. In the case of cost push inflation, a gain at one level of the chain is erased at another level, and all the agents in the value chain are worse off; therefore, inflation must be addressed and an environment created to enable investment in both agriculture and its dimensions (FAO 2012 a).

The diagnostic statistics for the estimated cointegrating regression equation are robust. The overall fit of the estimated model (adjusted R^2) indicates that the independent variables employed in the model jointly accounted for as much as 91% of the total variation in agricultural value chain output. The F-statistic and its associated probability indicate joint significance of all the variables employed in the estimated OLS model, implying that all the explanatory variables are jointly significant in determining the variation in the output of agricultural value chain. There is no evidence of autocorrelation, as attested to by the Durbin–Watson statistics. In addition, the model passes the test of normality: the Jarque–Bera statistics in the three regressions and their associated probabilities imply that the null hypothesis of the normally distributed error term cannot be rejected. Furthermore, the null hypothesis of heteroscedasticity is rejected in the OLS regression (respectively, autoregressive conditional heteroscedasticity (ARCH) and White statistics), indicating the constant variance of the stochastic error term. Overall, the model does not suffer from specification bias as shown by the non-significant t-statistic of Ramsey's regression equation specification error test (RESET).

Table 3 Estimated results
Panel A Long-run estimates
Dependent Variable: AVCO

	OLS		FMOLS		DOLS	
Variable	Coefficient	t–Statistic	Coefficient	t–Statistic	Coefficient	t–Statistic
Intercept	8.732^{*}	4.118	9.368^{*}	6.473	7.219^{***}	1.75
Cap	0.073^{*}	3.901	0.071^{*}	5.270	0.055^{**}	2.864
Lab	0.295^{*}	4.563	0.310^{*}	6.724	0.294^{*}	4.410
Infradev	0.670^{**}	2.669	0.613^{*}	3.386	0.898^{***}	1.739
Inf	–0.017	–0.967	$–0.001^{**}$	–2.508	–0.001	–0.507
Diagnostics						
R^2	0.76	0.79	0.91			
Adjusted R^2	0.72	0.75	0.81			
SER	0.043	0.041	0.0310			
F–statistic	16.218	–	–			
	(0.000)					
DW	2.09	–	–			
JB	0.227	0.135	0.799			
	(0.893)	(0.935)	(0.670)			
ARCH [χ^2, 1]	0.158	–	–			
	(0.691)					
WHITE [χ^2, 1]	5.151	–	–			
	(0.272)					
RESET	2.128	–	–			
	(0.467)					

Panel B Short-run estimates
Dependent Variable: Δ AVCO

Variable	Coefficient	Std. Error	t–Statistic
Δ Cap	0.033	0.023	1.435
Δ Lab(–1)	0.070	0.073	0.959
Δ Infradev	0.243^{***}	0.130	1.869
Δ Inf	$–0.001^{**}$	0.0004	–2.500
ECM(–1)	$–0.676^{**}$	0.242	–2.793
Diagnostics			
R^2	0.46		
Adjusted R^2	0.35		
SER	0.028581		
BG [χ^2, 1]	5.436		
	(0.143)		
JB	0.874		
	(0.646)		
ARCH [χ^2, 1]	0.149		
	(0.699)		
WHITE [χ^2, 1]	1.731		
	(0.885)		
RESET [t–statistic]	0.193		
	(0.849)		

Note Probability values are in parenthesis. Chi-square values and number of lags are in square bracket. SER: Standard error of regression; JB: Jarque–Bera test for normality of residuals; DW: Durbin–Watson test for autocorrelation; BG: Breusch"Godfrey Serial Correlation LM Test; ARCH: Engle's test for conditional heteroscedasticity; WHITE: White test for heteroscedasticity; RESET: Ramsey's residual specification error test.
Source Authors' computations.

Short-run estimates

In the short run (Panel B of Table 3), infrastructural development exerts a statistically significant positive impact on agricultural value chain output at the 10% level. Inflation, a measure of macroeconomic instability, has a statistically significant negative impact on agricultural value chain output at the 10% level. Although capital and labour are positively related to agricultural value chain output, they are not statistically significant in the short run.

The coefficient of the error correction mechanism (ECM) is negative (–0.676 in Panel B of Table 3) and statistically significant at the 5% level. The speed of adjustment is relatively high, as a deviation in agricultural value chain output from equilibrium is corrected by as much as 68% (approximately) the following year. The sign of the ECM coefficients validates the results of cointegration earlier reported in the study.

An examination of the post-estimation diagnostics of the estimated short-run model indicates that variations of about 35% in agricultural value chain output are explained by gross fixed capital formation, employment, infrastructural development, and macroeconomic instability. The Breusch–Godfrey statistics indicate acceptance of the null hypothesis of no serial autocorrelation. The Jarque–Bera test statistic is not statistically significant, an indication of normally distributed residuals. The null hypothesis of homoscedasticity is not rejected as shown by, respectively, the non-significant ARCH and White test results. The null of correct specification is accepted as indicated by the RESET test statistic.

Causality and stability tests

The Toda–Yamamoto causality test results are presented in Panels A and B of Table 4. The preliminary conditions for the Toda–Yamamoto test are satisfied (Appendix 2). Consequently, 1 lag was the preferred option (see Appendix Table 2A). There is no autocorrelation even up to 5 lags (see Appendix Table 2B). The VAR is stable (see Appendix Table 2 C and Figure 1). There is unidirectional causality from capital and labour to agricultural value chain output and from agricultural value chain output to infrastructural development (Table 4, Panels A and B). The null of no causality from all the variables to *Avco* is rejected as indicated by the significant (at 5%) chi-square statistic in Panel A. The implication of the causality results is that agricultural value chain output can be reasonably predicted given the information on all the explanatory variables employed in the study.

Table 4 Granger causality/block exogeneity test results

Panel A Causality from other variables to agricultural value chain output

Dependent variable: AVCO

Excluded	Chi–sq	df	Prob.
Cap	3.194	1	0.074
Lab	5.357	1	0.021
Infradev	2.362	1	0.124
Inf	2.099	1	0.147
All	11.163	4	0.025

Panel B Causality from agricultural value chain output to other variables

Independent variable: AVCO

Excluded	Chi–sq	df	Prob.
Cap	1.738	1	0.187
Lab	0.263	1	0.608
Infradev	5.418	1	0.019
Inf	1.603	1	0.206

Source Researchers' computations

The cumulative sum of recursive (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) tests, developed by Brown et al. (1975), were used to determine the stability of the estimated coefficients (Figures 1 and 2). Figures 1 and 2 indicate that both the CUSUM and CUSUMSQ plots do not

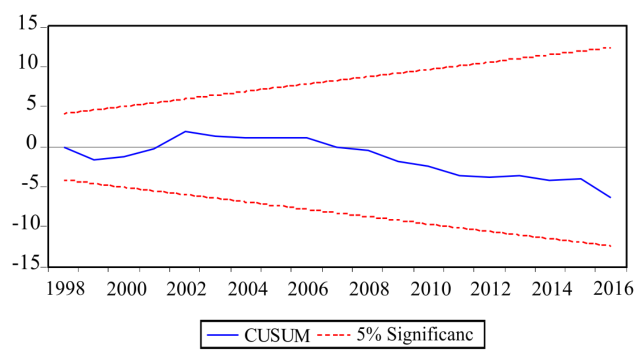

Figure 1 Plot of cumulative sum of recursive residuals

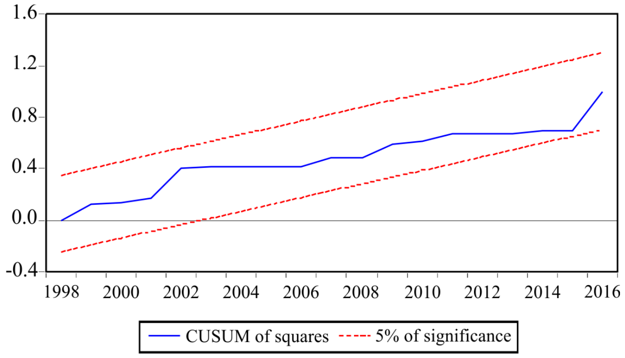

Figure 2 Plot of cumulative sum of recursive residuals

cross the 5% critical lines. The implication is that the stability of the estimated coefficients exists over the entire sample period of investigation. Thus, the parameters are constant in the estimated model. Policy making and recommendations are not out of place using the estimated coefficients.

Conclusions

This paper investigates the impact of infrastructural development in Nigeria from 1991 to 2016 on the agricultural value chain, particularly oil palm, in which we considered production and processing, comprising oil palm fruit production, oil palm processing, and oil palm kernel processing, with each stage having its output value in the chain. Capital was measured using gross fixed capital formation in agriculture, forestry, and fishing. Our measure of labour is employment in agriculture, while rail lines was used to measure infrastructural development. Inflation was taken as a measure of macroeconomic instability. We used a battery of techniques—OLS, fully modified OLS, and dynamic OLS—for the analysis.

A long-run equilibrium relationship was found to exist between agricultural value chain output, capital, labour, infrastructural development, and inflation. The empirical results indicate that capital, labour, and infrastructural development have significant positive impact on the agricultural value chain, while macroeconomic instability exerts the opposite impact. Importantly, in both the long and short run, infrastructural development has a significant positive impact on the agricultural value chain. Capital and labour were found to be positively related to agricultural value chain output and statistically significant in the long run, but the relationship was not statistically significant in the short run. Unidirectional causality was found to flow from capital and labour to agricultural value chain output and from agricultural value chain output to infrastructural development. It is noteworthy that the results from the FMOLS and DOLS frameworks are consistent with those of the OLS.

We conclude, thus, that infrastructural development has a statistically significant positive impact on agricultural value chain output and that the causality is unidirectional from infrastructural development to agricultural value chain output; infrastructural development in Nigeria spurs agricultural value chain and that the impact of the former on the latter is statistically significant. In essence, the agricultural value chain in Nigeria can be optimized if its development agenda is made to centre on infrastructural development. Based on the empirical findings, we make the following recommendations to optimize the agricultural value chain in Nigeria.

Access to capital should be improved; one way is to increase the budgetary allocation, another is to expand the capacity of banks (such as the Bank of Agriculture and Industry) to deliver on their mandate. Polices that promote commercial capacity to offer loans and advances to agricultural value chain activities (such as processing and distribution) need to be made and implemented.

In the agricultural sector in general and in agricultural value chain activities in particular, skills need to be improved and better skills promoted. Enhancing the capacity of the National Directorate of Employment and the Small and Medium Enterprises Development Agency of Nigeria will help in this regard.

Infrastructural development should be given top priority by governments at all levels if the benefits accruing from value chain in Nigeria are to be realized. Developing new railway lines and rehabilitating existing ones can spur growth in agriculture in general and improve the movement of outputs at various stages of the value chain, thereby reducing transport cost and minimizing waste.

Macroeconomic instability and distortions need to be carefully managed to obviate its negative impact on the development of agricultural value chain.

Future research in agricultural value chains is likely to benefit from the results of the present study; however, such research needs to explore the micro or cross-sectional dimensions of the agricultural value chain, in addition to panel studies. Findings from such vastly unexplored aspects of the Nigerian economy are likely to impact current thinking in the area, while enriching the empirical literature.

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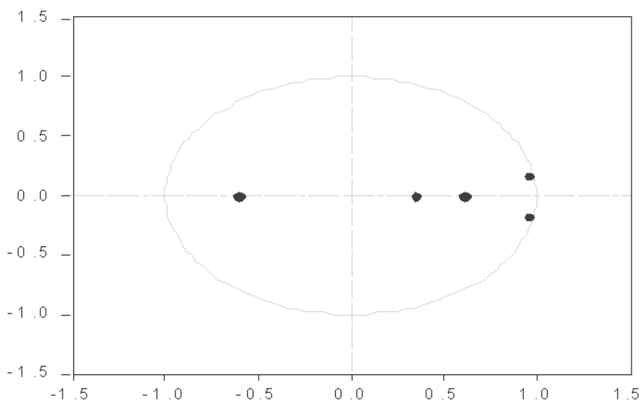
Appendix Table 1 Descriptive statistics and correlation matrix

	Avco	Capital	Labour	Infradev	Inf
Descriptive statistics					
Mean	16.022	7.264	3.744	8.145	2.672
Median	16.021	7.367	3.886	8.168	2.529
Maximum	16.120	8.673	3.953	8.177	4.288
Minimum	15.821	6.048	3.303	8.024	1.683
Std. Dev.	0.081	0.986	0.247	0.049	0.699
Jarque–Bera	2.327	3.199	4.867	18.845	4.416
Probability	0.312	0.202	0.088	0.000	0.110
Correlation matrix					
Avco	1.000				
Capital	0.461	1.000			
	(0.021)	–			
Labour	–0.036	–0.827	1.000		
	(0.864)	(0.000)	–		
Infradev	0.696	0.576	–0.378	1.000	
	(0.000)	(0.003)	(0.063)	–	
Inf	–0.603	–0.503	0.309	–0.676	1.000
	(0.001)	(0.010)	(0.133)	(0.000)	–

Note values in parenthesis are probabilities.
Authors' computations



Appendix Figure 1 Inverse roots of AR characteristic polynomial
Authors' computations

Appendix Table 2 TY causality test diagnostics

Table 2A VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	56.509	NA	7.81e–09	–4.479	–4.232	–4.417
1	146.851	133.549*	2.83e–11*	–10.161*	–8.679*	–9.788*
2	170.218	24.383	4.69e–11	–10.019	–7.304	–9.336

* indicates lag order selected by the criterion
Authors' computations

Table 2B VAR residual serial correlation LM tests

Lags	LM–Stat	Prob
1	25.182	0.452
2	24.123	0.512
3	18.313	0.829
4	22.619	0.599
5	23.991	0.520

Authors' computations

Table 2C Roots of characteristic polynomial

Root	Modulus
0.959 – 0.176i	0.974
0.959 + 0.176i	0.974
0.612	0.612
–0.604	0.604
0.349	0.349

No root lies outside the unit circle.
VAR satisfies the stability condition.
Authors' computations