Revisit of Road Transport Infrastructure Contribution to Agriculture Output: Empirical Validation for the Case of Nigeria

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Abstract

This study examines the impact of road transport infrastructure quality on agricultural output in Nigeria from 2000 to 2022. This study used secondary data which were subjected to Augmented Dickey-Fuller Unit root test, ARDL bounds test approach for cointegration, and Canonical Cointegrating Regression method. Arable land (LNARAB) and average temperature (LNTEMP) depicted positive influence on agricultural output while road transport infrastructure quality (LNROADQ), average rainfall (LNRAIN) and carbon dioxide emission (LNCO2) exerted negative impact on agricultural output. Nevertheless, effective road network remains a vital factor to the economic prosperity of any country because of its role in driving commerce and transportation. As such, government of Nigeria should increase funding by increasing the budgetary allocation to the Federal Ministry in charge of transport infrastructure development. In the same manner, local production of bitumen should be encouraged so that the cost of road construction can reduced.

Keywords: transport infrastructure, economic growth, canonical cointegrating regression, agriculture development.

1. Introduction

In West Africa, Nigeria's road network is the biggest. The country has approximately 195,000 km of road interconnection of which roughly 60,000 km are paved as of 2019 (Styles, 2020). As indicated by the Government Infrastructure Concession Regulatory Commission, nearly all the significant road networks were established in the 80s and early 90s. The condition of roads had depreciated, due to poor preservation and inferior materials used for repairs. Travelling is extremely tough and occasionally futile in numerous parts on secondary roads (i.e. roads connecting locally essential centres to each one, to a very significant centre or a fabulous class road (rural/market centres) and connection between locally critical traffic generators and their rural remote areas) throughout the raining season as a consequence of potholes and disintegrated, bumpy surfaces.

The paramount expressways in Nigeria run from South to North and were intended to transport produce from the remote areas to the coast for export as well as to join the economies of old Northern and Southern Nigeria. These expressways are designated A1, A2, A3 and A4. The A1 expressway is a paramount road in Nigeria, linking Lagos in the south to the boundary alongside Niger in the north at

Birnin Konni. The A2 expressway is a federal expressway in Nigeria which stretches 1,200 kilometres (750 mi). It is a crucial transportation path, joining the country's southern and northern zones (Sbmintel.com, 2017). The A3 expressway is a paramount highway in Nigeria, linking the town of Port Harcourt in the south to the Cameroon boundary at Gamboru in the northeast. The A4 expressway is a paramount north-south thoroughfare in Nigeria which stretches across the southern coast to the eastern interior areas (Nigeria, 1985). Every other paramount roadway in the nation emerged from the aforementioned.

The government of Nigeria earmarked N295 billion ($819mil) in its 2018 budget for roadway capital works and sustenance on some initiatives e.g. Road Infrastructure Development and Refurbishment Investment Tax Credit Scheme, Presidential Infrastructure Development Fund (PIDF), Highway Development Initiative) enhance and sustain these principal expressways (Styles, 2020). N124bn was recommended for the Construction/Provision of Roads in 2019 (Adugbo, 2019), N362. 56 bn in 2020, N612. 56 bn in 2021, and N742. 56 bn in 2022 correspondingly (FMWH, 2023).

In terms of nature, there exist various types of infrastructure overlaying economic, financial, technological, social, agricultural, transport, etc. Amidst the aforementioned infrastructures, transport contributes a supreme position since it can induce industrial and agricultural sectors support to the expansion of economies across the globe. For example, in various regions of the world, farmers and producers reside a long way from the locations where their products are marketed. This implies that several of the supplies have to be conveyed to collation venues, notwithstanding whether it is for stockpiling or sale. Roadway conveyance plays a critical part in narrowing the gap between remote farming places, extracting installations in industrial zones, and eventually, the city customers and enterprises, accelerating effective crop dissemination.

In Nigeria, agriculture is largely segregated into four sections - crop production, fishing, livestock and forestry. Crop production continues to be the greatest section and it constitutes approximately 87.6% of the sector's aggregate production. Following that are livestock, fishing and forestry at 8.1%, 3.2% and 1.1% correspondingly (Oyaniran, 2020). Agriculture continues to be the biggest sector in the country providing approximately 24% of the nation's GDP in the last few years (2013 – 2019) (Oyaniran, 2020). Additionally, the sector engages above 36% of the nation's workforce, a performance that rates the sector as the greatest employer of workers in the entire nation (Oyaniran, 2020).

Nevertheless, several research-based studies have been conducted on road transport infrastructure and agricultural output in Nigeria and around the world (Khandker, 1989; Fan et al., 2000; Palwinder and Jasmindeep, 2014; Fungo et al., 2017; Soumya and Elumalai, 2015; Stephen, 2015; Spey et al., 2019); (Abdulraheem, et al., 2021; Ogunleye et al., 2018; Adepoju and Salman, 2013; Tunde and Adeniyi, 2012; Onakoya, et al, 2012; Ighodaro, 2011; Inoni and Omotor, 2009).

Despite the relatively rich literature on road transport infrastructure and agricultural growth in Nigeria, few studies carefully examine the impacts of road transport infrastructure quality on the agricultural sector. However, with several initiatives and programmes to improve transport infrastructure as well as public sector reforms in Nigeria in recent times, it becomes necessary to analyse the impact of road transport infrastructure quality on agricultural output in Nigeria. The emphasis is on the quality of road infrastructure. This is because agricultural produce is different from industrial goods, and has certain peculiar characteristics, because of which the quality of road transportation infrastructure becomes as important as the availability of transport. The remaining sections are organized as follows: Section II is an empirical review. Section III discusses the methodology and data source as well as the estimation technique. Section IV presents the results and discussion while section V is for summary, conclusion and recommendation.

2. Empirical Review

Several studies have been carried out concerning the connection between road infrastructure and agriculture production in developing nations. The evidences of research on the subject matter are mixed across countries, data and methodologies. For instance, Mukonyo et al., (2022) assessed the effect of roadway transportation infrastructure on agricultural competitiveness in Zimbabwe. The study adopted a cross-sectional method. The outcome revealed that a 10% decline in transportation and waiting time costs brought about a 10% rise in agricultural production.

Fungo et al., (2017) examined the role of road infrastructure in agricultural production in Tanzania using the 2012/13 data from the Tanzania National Panel Survey (NPS). The outcome indicated a favourable effect on crop yield as a result of the drop in transport price by -0.291 elasticity. Tamene & Megento (2017) investigated access to rural road infrastructure and its consequences on smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone, Western Ethiopia. The outcome of the multiple regression model deployed depicted that distance to major markets is crucial in forecasting Abe Dongoro, Amuru and Hababo Guduru district's smallholder farmers' agricultural productivity at 5% levels of probability.

In Nigeria, Inoni & Omotor (2009) evaluated the impact of road infrastructure on agricultural production in Delta State. Analyzing household agricultural production and income data which were derived from 288 rural inhabitants, the outcome depicted that rural roads have a substantial positive impact on the output of agriculture. Oladosu et al., (2018) evaluated the impact of rural transport infrastructure on agricultural produce on farmers' income. Descriptive as well as inferential statistics were utilized to examine the collated data. The outcome revealed that the principal crop cultivated in the region is yam and head, while loads were the main technique of conveyance.

Ogunleye et al., (2018) evaluated the influence of road transport infrastructure on agricultural sector growth in Nigeria from the period 1985 to 2014. Granger Causality test along with Ordinary Least Square evaluation methods were employed to analyze the data. The research concluded that a positive and statistically meaningful link exists between road transport infrastructures and agriculture production.

Olorunfemi (2020) investigated how road infrastructural difficulties hinder the expansion of agriculture in Idanre Local Government Council Areas, Ondo State, Nigeria. A stepwise regression technique was utilized. The outcome disclosed that a high cost of transportation and inconsistent transport services owing to the miserable condition of the roads in the area of study have obstructed successful agricultural advancement.

Furthermore, Tunde & Adeniyi (2012) evaluated the effect of road transport on agricultural development in Ilorin East L.G.A. Kwara State. Descriptive together with analytical statistical techniques were engaged to scrutinize the data collated. The research discovered that road transport has both positive and negative influences on agricultural advancement. In the same vein, Orakwue et al. (2015) evaluated the influence of road transport on agricultural productivity in Anambra state, Ayamelum Local government area in particular. To accomplish the aim of the research, descriptive and graphical techniques were utilized. The outcome revealed that road transport has both negative and positive influences on agricultural advancement.

Given the foregoing literature, there is a need to re-examine road transport infrastructure contribution to agriculture output in Nigeria considering the gap uncovered in the scope of the majority of the works revisited. The proofs from the studies are inconsistent, and data and methodologies are mixed. Moreover, some of the works were done before the year 2022. As such, this study deployed the Canonical Cointegration Regression technique because it addresses data imperfections, such as missingness, heterogeneous frequency, and evaluation inaccuracies, which constitute supplementary noise that may contravene covariance stationarity assumptions on the model error (Miller, 2009). Furthermore, this study increased the period and included a relevant variable, i.e. carbon dioxide emission (CO_2) (a proxy for climate change), also, climatic events such as temperature and rainfall variations which considerably alter the yield of crops were incorporated.

3. Methodology

3.1 Theoretical Framework

The study relies on the theory of production function and infrastructure-driven development theory. To put it simply, the theory of the production function describes the connection between the physical outputs of a production process and physical inputs, i.e. factors of production.

A simple production function can be articulated in a functional form as the right side of:

$Q = f\ (X_1, X_2, X_3, \ldots, X_n)$ ……………………….(1)

Where Q is the quantity of output and $X_1, X_2, X_3, \ldots, X_n$ are the quantities of factor inputs (such as capital, labour, land or raw materials). For $X_1 = X_2 = \ldots = X_n = 0$ it must be $Q = 0$ since we are incapable of producing anything without inputs.

If $\boldsymbol{Q}$ is a scalar, then this conformation does not incorporate joint production, which is a production process that has numerous co-products. Under other circumstances, if f maps from $\mathbf{R}^n$ to $\mathbf{R}^k$ then it is a joint production function depicting the determination of k various kinds of output in accordance with the joint application of the stipulated quantities of the n inputs.

One formulation is as a linear function:

$Q = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \ldots. + \alpha_n X_n$ ……………………………(2)

Where $\alpha_1, \ldots, \alpha_n$ are parameters that are resolved empirically. Linear functions imply that inputs are perfect substitutes in production. Another is as a Cobb–Douglas production function:

$$Q = \alpha_0 X_1^{\alpha_1} X_2^{\alpha_2} \ldots X_n^{\alpha_n}$$

Where $\boldsymbol{\alpha_0}$, is the so-called total factor productivity.

The infrastructure-driven development theory fuses vital policy characteristics handed down from the Rooseveltian progressive tradition and neo-Keynesian economics in the United States, France's Gaullist and neo-Colbertist centralized economic planning, Scandinavian social democracy along with Singaporean and Chinese state capitalism: it maintains that a significant fraction of a country's resources ought to be methodically channelled towards long term assets, for instance, transportation, energy and social infrastructure (schools, universities, hospitals) in the name of long term economic efficacy (encouraging progress in economically backward areas and promoting technological innovation) and social equity (delivering free education and cost-effective healthcare) (Firzli & Bazi, 2011; Rephann & Isserman, 1994).

As indicated in a study by Aschauer (1990), there exist a positive and statistically significant correlation between investment in infrastructure and economic performance. To substantiate his point, Aschauer created a model and used the data for the time period from 1953 to 1988 to simulate the effect of higher public investment on the aggregate economy. His simulation reveals that, on the net, the rise in investment in core infrastructure might potentially have largely enhanced the performance of the economy.

Aschauer uses the production function $Y = F(K,G,N,Z) = ZK^{\alpha} G^{\beta} N^{1-\alpha-\beta}$ ………(3)

where: Y is level of output, K is private fixed capital, G is level of government productive services, N is population or labor force, Z is index of technological progress, α and β are constants determined by available technology.

3.2 Model Specification

Following the literature (e.g., Aschauer, 1990; Gyimah-Brempong, 1987; Bravo-Ortega and Lederman, 2004, Iimi et al., 2018), a simple production function (in terms of agriculture production) is considered with road transport infrastructure included as one of the production inputs besides other traditional production inputs considered:

InŸ$_t$ = $\psi_0 + \psi_1$InŤ$_t$ + ψ_2InŘ$_t$+ ɲ$_t$ …………. (4)
where Ÿ is the volume of agricultural output(tones); Ť is traditional production inputs considered (LNARAB is arable land (in hectares); LNFERA is fertilizer consumption (kilograms per hectare of arable land); LNLAB is labour force; LNRAIN is average rainfall (mm per year); LNTEMP is average temperature (0 C) (Celsius)); LNCO2 is carbon dioxide emission (kiloton (kt)) proxy for climate change; Ř is road transport infrastructure quality (LNROADQ); In is natural logarithm; and ɲ is the random term.

Expressing equation (4) in an explicit form, the model can be stated as:
LNAGO$_t$ = Ϫ$_0$ + Ϫ$_1$LNLAB$_t$ + Ϫ$_2$LNRAIN$_t$ + Ϫ$_3$LNROADQ$_t$ + Ϫ$_4$LNTEMP$_t$ + Ϫ$_5$LNCO2$_t$ + Ϫ$_6$LNARAB$_t$ + Ϫ$_7$LNFERA$_t$ +Ҿ$_t$ ……………(5)
Where: *AGO* is agricultural output; *LNLAB* is labour force; *LNRAIN* is average rainfall; *LNROADQ* is road transport infrastructure quality; LNTEMP is average temperature; *LNCO2* is carbon dioxide emission; *LNARAB* is arable land; *LNFERA* is fertilizer consumption; Ϫ$_0$ is intercept; Ϫ$_1$- Ϫ$_7$ are parameters of the explanatory variables that are captured in the model; LN is natural logarithm; Ҿ = error term; and t is time. Apriori expectation: Ϫ$_1$, Ϫ$_2$, Ϫ$_3$, Ϫ$_4$, Ϫ$_6$, Ϫ$_7$,>0< Ϫ$_5$.

3.3 Data and Estimation Techniques

This study used secondary data spanning from 2000 to 2022 obtained from World Development Indicators, theglobaleconomy.com, indexmundi.com, tradingeconomics.com, countryeconomy.com, worlddata.info, and Statistical Bulletin and Annual Report and Statement of Accounts published by the Central Bank of Nigeria (CBN). The data were subjected to stationary tests using the Augmented Dickey-Fuller Unit root test, and the ARDL bounds test approach for cointegration was deployed to test for the existence of long-run relationships among the variables. Thereafter, the estimation of the cointegrating relationship using the Canonical Cointegrating Regression method was carried out. The Canonical Cointegration Regression (CCR) of Park (1992) is among the newly advanced econometric approaches for evaluating cointegrating equations. These techniques offer a check for the robustness of the outcome and can render credible estimates in small sample sizes.

According to Park (1992), the Canonical Cointegrating Regression (CCR) technique uses the stationary transformation of the (yt, X't) data to achieve least squares estimates to eradicate the long-run dependency between the cointegrating equation and stochastic regressors innovations. The CCR transformations asymptotically erase the endogeneity created by the long-run correction of the cointegrating equation errors and the stochastic regressor innovations, and simultaneously correct for asymptotic bias resulting from the contemporaneous correlation between the regression and stochastic regressors errors. Estimates based on the CCR are therefore fully efficient and have an unbiased, mixture of normal asymptotic.

The canonical cointegration regression takes the following form:
$y_{1t}^{*} = \beta' y_{2t}^{*} + u_{1t}^{*}$ ……………….(6)
Where, $u_{1t}^{*} = u_{1t} - \Omega_{12}\Omega_{22}^{-1}u_{2t}$ ……………(7)

Consequently, in this setting, the OLS estimator of (6) is asymptotically commensurate to the modified ordinary least squares (ML) estimator. The reason is that the transformation of the variables eliminates asymptotically the endogeneity created by the long-run correlation of y_{1t} and y_{2t}. Additionally, equation (7) depicts how the transformation of the variables eliminates the asymptotic bias as a result of the attainable cross correlation between u_{1t}, and u_{2t}.

4. Results and Discussion

4.1 Unit Root Test

This is the first and very important step, it is revealed from the literature that most of the time series variables are non-stationary, and using nonstationary time series on another non-stationary time series in the model might bring about erroneous regression outcome (Granger, 1986). That being the case, the Augmented Dickey-Fuller (ADF) unit root test was deployed. The null hypothesis of ADF tests is that there is a unit root in the series, whereas the alternative hypothesis indicates that there is no unit root in the series. Each of the series would be differentiated until it becomes stationary. A series which is stationary at level is denoted by *I(0)*and stationary at first difference is denoted by *I(1)*.

The Augmented Dickey-Fuller (ADF) unit root test in this study was performed using the Schwarz information criterion and the automatic lag selection set at 4 lags. The test was conducted using intercept, trend and intercept at levels and then at first difference. Only test regressions that are integrated of order zero, that is, I(0) or test regressions that are integrated of order one, that is, I(1) are reported. The result in Table 1 shows that the variables employed are a mixture of I(0) and I(1) variables. Therefore, an autoregressive distributed lag (ARDL) model procedure of the cointegration test can be applied to this study.

Table 1: Augmented Dickey Fuller (ADF) Unit Root Results

Variable	ADF test				Order of Integration
	Levels		1st difference		
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	
LNAGO	-1.533607	-3.831620**	---	---	I(0)
LNLAB	3.457457	-1.247874	-4.457404*	---	I(1)
LNRAIN	-2.101127	-2.042642	-12.99423*	---	I(1)
LNROADQ	-2.040552	-2.275920	-6.124014*	---	I(1)
LNTEMP	-3.886835*	---	---	---	I(0)
LNCO2	-2.089835	-2.637268	-5.099276*	---	I(1)
LNARAB	-2.551935	-3.645766**	---	---	I(0)
LNFERA	-0.519245	-4.047487**	---	---	I(0)

Note: ADF test was performed using Schwarz information criterion and the automatic lag selection set as 4 lags. Also, *, ** and *** imply statistical significance at 1%, 5% and 10% levels respectively.

Source: Author's computation using Eviews 10

4.2 ARDL Bound Test (Cointegration Test)

The study adopted an autoregressive distributed lag (ARDL) model bounds test approach for cointegration to test for the existence of cointegration within the variables for the long-run association. In carrying out the ARDL bounds testing, the model is specified in its original form where LNAGO is the dependent variable and LNLAB, LNARAB, LNFERA, LNRAIN, LNTEMP, LNCO2, and LNROADQ are independent variables. Due to the sample size, the study chose a maximum lag length of 1 for the dependent and independent variables. In addition, the specification was with Restricted Constant and No Trend, and the model selection criteria was Akaike information criterion. The rule of ARDL bounds testing is that if the computed F-statistic falls below the lower bound we would conclude that the variables are I(0), so no cointegration is possible, by definition. If the F-statistic exceeds the upper bound, we conclude that we have cointegration. Finally, if the F-statistic falls between the bounds, the test is inconclusive.

The bounds test for cointegration in Table 4 indicates that the computed F-statistic of 8.325562 is greater than the lower and upper bounds critical values of 2.73 and 3.9 respectively, at the 1 per cent significance level. Therefore, the null hypothesis of no cointegration is discarded, meaning that there is evidence of a long-run relationship among LNAGO, LNLAB, LNARAB, LNFERA, LNRAIN, LNTEMP, LNCO2, and LNROADQ. The satisfaction of cointegration leads to the estimation of this single equation cointegrating relationship using the Canonical Cointegrating Regression method.

Table 2: F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	8.325562	10%	1.92	2.89
k	7	5%	2.17	3.21
		2.5%	2.43	3.51
		1%	2.73	3.9

Source: Author's computation using Eviews 10+

4.3 Long-Run CCR Estimates

The results of the estimated model employing the CCR method are presented in Table 3. The result of this study revealed that road infrastructure quality (LNROADQ) is negatively associated with the volume of agricultural output. This inverse relationship is statistically significant at a 5% significance level. This result is not in conformity with Inoni & Omotor (2009), Kassali et al., (2012), and Ogunleye et al., (2018) who concluded that roads have a significant positive effect on agricultural output in Nigeria. The negative result obtained in this present study is not surprising as it was disclosed that approximately 70% of road infrastructure is deficient in Nigeria. The paved road network in the country is just 50,000km out of 200,000km (Tunji, 2022). It is noteworthy that the neglect given to road infrastructure in Nigeria is the reason that the transport sector in the country is underperforming. It also explains why the contribution of the sector to the gross domestic product (GDP) has been on a downward trend (The Editorial Board, 2021).

As expected, climate change (LNCO2) has a negative and statistically significant impact on the volume of agricultural output. This is because carbon dioxide emission (CO2) via their straight-off effect on inconsistent rainfall, drought, and flood, distort agricultural productivity. As Population Matters (2024) reported, Nigeria emitted 129 metric tons of CO2 in 2023, the 4th topmost emissions in Africa. The greater part of Nigeria's emissions originates from oil and gas production, and the process of "gas venting", where undesired gases that appear in the course of oil production – mainly methane – are discharged into the atmosphere. Methane is a greenhouse gas 28 times more powerful than carbon dioxide. Likewise, "gas flaring", is the process of burning off surfaced gases, discharging carbon dioxide as a by-product which increases emissions. Approximately 6.6 billion cubic metres of gas was flared in Nigeria in 2021 – ranking it as the world's 7th biggest gas flarer. Nevertheless, the result of this study shows that agricultural output decreases by about 1.572431% for every 1% increase in carbon dioxide emission (climate change) and the coefficient is statistically significant at a 1% significance level. This result aligns with Eregha et al., (2014) findings that carbon emission has a significantly negative impact on crop production in Nigeria.

Similarly, average rainfall (LNRAIN) is shown to have a negative and significant effect on the volume of agriculture in the period covered in this study. One plausible reason could be because of the intensity or magnitude of rainfall irregularity and extremities which is an obvious characteristic of the Nigerian climate, especially in the northern area where serious droughts have interchanged with floods times past. Specifically, the rainfall pattern varies from a wet coastal area with an annual rainfall greater than 3,500 mm to the Sahel region in the north, with an annual rainfall of less than 600 mm (NATCCC, 2022). The outcome of this study is not in line with Eregha et al., (2014) findings that rainfall has a significantly positive effect on crop production in Nigeria. Also, the result does not agree with Terfa (2012) who revealed that rainfall had a positive but insignificant influence on food supply (agriculture output) in Nigeria.

Though rainfall and temperature sequences have adjusted geographically in Nigeria as a result of climate change prompted by carbon emissions, with some areas experiencing extreme rainfall and heat and vice versa, however, the result of this study shows that average temperature (LNTEMP) has a positive and statistically significant on agriculture output. The estimated coefficient of 28.69286 indicates that agricultural output increases by about 28.69286% for every 1% increase in average temperature (LNTEMP) and it is statistically significant at 1% level. This result does not support Eregha et al., (2014) study which revealed that temperature had a significantly negative influence on crop production (agriculture output). Also, the result does not agree with Terfa (2012) who revealed that temperature had a positive but insignificant influence on food supply (agriculture output) in Nigeria.

The coefficient associated with labour force (LNLAB) variable appeared to be positive but statistically insignificant. This implies that labour force has no impact on the volume of agricultural output. Noteworthy, agriculture is Nigeria's largest employer of labour, responsible for approximately 60% of the labour force, working primarily in small-holdings applying rudimentary tools (Iproject.com, 2023). Although agricultural employment portion appears remarkably at 48.19 percent (National Bureau of Statistics report for the third quarter of 2017), there has been a downward trend since 2001. In the remote area where agricultural activities prevail, there exist immense unemployment rate assessed at 25.6 % (Shani and Musa, 2021).

The estimated coefficient of arable land (LNARAB) is positive and theoretically plausible. This implies that an increase in arable land (LNARAB) leads to an increase in agricultural output in Nigeria. But as reported by ARISENEWS (2023), out of 70-80 million hectares of arable land in the country, just 34 million hectares are cultivated, implying that there is abundant uncultivated arable land for government and Nigerians to explore for farming and by extension, ensuring food security in the country. Specifically, Table 3 revealed that agricultural output increases by about 3.244140% for every 1 % increase in the arable land (LNARAB) and this relationship is significant at a 10% level of significance.

The estimated coefficient of fertilizer consumption (kilograms per hectare of arable land) (LNFERA) appeared positive and theoretically plausible. This implies that an increase in fertilizer consumption leads to an increase in agricultural output in Nigeria. However, Nagy & Edun (2002) observed that inadequate fertilizer usage rate abides in Nigeria notwithstanding that the government has been conspicuously involved in acquiring and apportioning fertilizer. Fertilizer has also been subsidized by both state and federal governments, but the subsidy programmes have been bedevilled by prevalent complications of late distribution of fertilizer, and delivery of inadequate quantities and kinds of fertilizer. Rent-seeking activities and political exploitation have also culminated in subsidized fertilizer diverted from the designated beneficiaries. The estimates from this study show that if fertilizer consumption (kilograms per hectare of arable land) (LNFERA) rises by 1%, the volume of agricultural output will correspondently rise by 0.048624% in the long run, though the coefficient of fertilizer consumption is not substantial and also not significant.

Table 3: Long-Run CCR Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLAB	0.503143	0.834936	0.602612	0.5564
LNARAB	3.244140	1.557531	2.082874	0.0561***
LNFERA	0.048624	0.194438	0.250074	0.8062
LNRAIN	-2.416581	1.202984	-2.008822	0.0642***
LNTEMP	28.69286	6.050807	4.741989	0.0003*
LNCO2	-1.572431	0.476395	-3.300688	0.0053*
LNROADQ	-2.972726	1.295332	-2.294952	0.0377**
C	-123.4384	33.48428	-3.686459	0.0024*

R-squared	0.595787	Mean dependent var	5.126299
Adjusted R-squared	0.393681	S.D. dependent var	0.288638
S.E. of regression	0.224753	Sum squared resid	0.707193
Long-run variance	0.020763		

Note: *, ** and *** imply statistical significance at 1%, 5% and 10% levels respectively. Source: Author's computation using Eviews 10

4.4 Post-Estimation Diagnosis

The diagnostic tests here are used to judge the quality of the model in terms of efficiency, convenience, fitness and flawlessness. In Table 4, the Correlograms Q-Statistics were deployed to conduct the residual test for serial correlation. The dotted lines in the plots of the autocorrelations (AC) are the approximate two standard error bounds computed. If the autocorrelation is within these bounds, it is not significantly different from zero at (approximately) the 5% significance level. In this case, the AC is within the standard error bounds, meaning it is not significantly different from zero for all lags. Similarly, the dotted lines in the plots of the partial autocorrelations PAC) are the approximate two standard error bounds computed. If the partial autocorrelation is within these bounds, it is not significantly different from zero at (approximately) the 5% significance level. In this case, the PAC is within the standard error bounds, meaning it is not significantly different from zero for all lags. The last two columns reported in the correlogram are the Ljung-Box *Q*-statistics and their *p*-values. The *Q*-statistic at lag is a test statistic for the null hypothesis that there is no autocorrelation up to order 12. From the Correlogram in Table 4, the Q-statistics are insignificant at all lags as depicted by their probability value, indicating insignificant serial correlation in the residuals of the model. That is, there is no presence of serial correlation.

Lastly, the Jarque-Bera test statistic (1.347154) for normality based on regression residuals indicates that the residual of the model is normally distributed since the p-value of 0.509881 is greater than the significance level of 5% i.e., 0.509881 >0.05 (see Figure 1).

Table 4: Correlograms Q-Statistics

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
. | . |	. | . |	1	0.050	0.050	0.0639	0.800
. |* . |	. | . |	2	0.074	0.072	0.2101	0.900
. *| . |	. *| . |	3	-0.134	-0.143	0.7115	0.870
***| . |	***| . |	4	-0.350	-0.351	4.3084	0.366
. | . |	. |* . |	5	0.055	0.116	4.4034	0.493
.**| . |	. *| . |	6	-0.208	-0.197	5.8293	0.443
. | . |	. *| . |	7	-0.008	-0.119	5.8315	0.560
. *| . |	. *| . |	8	-0.092	-0.189	6.1513	0.630
. *| . |	. *| . |	9	-0.156	-0.183	7.1428	0.622
. |* . |	. | . |	10	0.137	-0.018	7.9639	0.632
. |* . |	. |* . |	11	0.166	0.153	9.2822	0.596
. | . |	.**| . |	12	-0.000	-0.267	9.2822	0.679

Source: Author's computation using Eviews 10

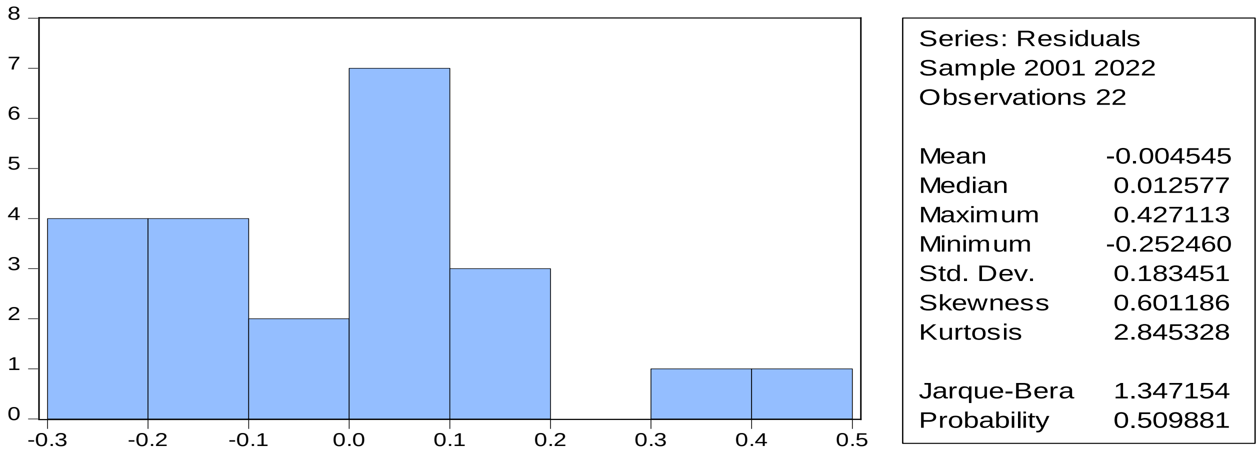

Figure 1: Normality Test
Source: Extracted from Eviews 10

5. Summary, Conclusion and Recommendations

This study examines the impact of road transport infrastructure quality on agricultural output in Nigeria within the time frame of 2000 to 2022. This study used secondary obtained from World Development Indicators, theglobaleconomy.com, indexmundi.com, tradingeconomics.com, countryeconomy.com, worlddata.info, and Statistical Bulletin and Annual Report and Statement of Accounts published by the Central Bank of Nigeria (CBN). The data were subjected to stationary tests using the Augmented Dickey-Fuller Unit root test. Furthermore, this study employed the ARDL bounds test approach for cointegration to test for the existence of cointegration among the variables. Thereafter, the estimation of the cointegrating relationship using the Canonical Cointegrating Regression method was carried out.

The result showed that arable land (LNARAB), average rainfall (LNRAIN), average temperature (LNTEMP), climate change (LNCO2), and road transport infrastructure quality (LNROADQ) showed a significant impact on the volume of agricultural output. Arable land (LNARAB) and average temperature (LNTEMP) depicted a positive influence on agricultural output while road transport infrastructure quality (LNROADQ), average rainfall (LNRAIN) and climate change (LNCO2) exerted a negative impact on agricultural output.

Specifically, agricultural output increases by about 3.244140% for every 1 % increase in the arable land (LNARAB). The estimated coefficient of 28.69286 indicates that agricultural output increases by about 28.69286% for every 1% increase in average temperature (LNTEMP). Agricultural output decreases by about 1.572431% for every 1% increase in climate change (LNCO2). A 1% increase in average rainfall (LNRAIN) leads to an approximately 2.416581% decrease in agricultural output. Agricultural output decreases by about 2.972726% for every 1% increase in road transport infrastructure quality (LNROADQ).

The coefficient associated with the labour force (LNLAB) variable is positive but statistically insignificant. Also, the labour force (LNLAB) and fertilizer consumption (kilograms per hectare of arable land) (LNFERA) showed a positive but insignificant impact on agricultural output.

In conclusion, road transport infrastructure quality (LNROADQ) exerted a negative impact on agricultural output. However, an effective road network remains a vital factor in the economic prosperity of any country because of its role in driving commerce and transportation. As such:

i. The government of Nigeria must increase funding by increasing the budgetary allocation to the Federal Ministry in charge of transport infrastructure development.
ii. The Federal government must invest in the rehabilitation and construction of roads connecting various parts of the country.
iii. Local production of bitumen should be encouraged so that the cost of road construction can reduced.
iv. The federal government must augment its financial allotment to the agricultural sector, make policies purposely aimed at alleviating the impact of climatic change on agriculture

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