Dynamic Interactions among Road Transport Infrastructural Development, Agricultural Growth and Poverty Level in Nigeria

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Abstract

The study investigated the dynamic interaction among road transport infrastructural development, agricultural growth and poverty level in Nigeria. It examined the nature and direction of causality among road transport infrastructural development, agricultural output and poverty level in Nigeria. This was with the view to providing empirical evidence on the linkages among road transport infrastructure, agricultural output and poverty level. The data on road transport infrastructural development, agricultural growth and real consumption expenditure per capita used in proxy poverty level were sourced from the statistical bulletins of the Central Bank of Nigeria and the National Bureau of Statistics, Abuja. Vector Error Correction Model (VECM) was used to determine the interaction effects among the three variables, while the pair-wise granger causality test was used to determine the direction of causality among variables. The result showed that one percent innovation in both road transport infrastructural development and real consumption expenditure per capita brought about a positive response by agricultural output; and although a shock to road infrastructure produced a negative response by real consumption expenditure per capita, it became positive over time. Moreover, there was increase in positive response of real consumption expenditure per capita as a measure of poverty due to an innovation in agricultural output. This was also complimented by the causality result which revealed that both agricultural output and road transport infrastructural development granger-cause poverty reduction through real consumption expenditure per capita in Nigeria.

Keywords: Economic growth, road transport, poverty level, cointegration, VAR agricultural output

JEL Classifications: L62, N57, O13, Q11

Introduction

The presence of an adequate, reliable and efficient transport system is a critical factor in local economy development. A well-developed transport infrastructure provides adequate access to local communities, which is a necessary condition for the efficient operation of manufacturing, retail, labour and housing markets.

Transport is a wealth-creating industry on its own, as well as the life-line of an economy. By 'lifeline', it means that transport is extremely important for the survival of an economy (Olubomehin, 2012).

Moreover, agriculture constitutes an important part of most low-income economies. Generally, agriculture is the primary source of income in rural areas, both directly through crop production and indirectly through on-farm and off-farm employment in agriculture-related industries (Haggblade, 1989). The importance of improved rural infrastructure, especially rural roads, is not new and cannot be ruled out in community development. Economists claim that rural goods are always at the centre of development policies; and this is supported by an assumption among development theorists that the disadvantageous position of remote areas, vis-a-vis economic opportunity and social welfare, can be improved with road building (Bryceson, 2008). Investments in rural infrastructure were considered to have important positive effects on agricultural production and trade; hence, governments and other donors invest heavily in the development of rural roads and transport corridors because of their importance to general economic development. Evidence on how and under what conditions roads benefit rural and agricultural development remains an empirical issue.

The need to achieve self-sustaining and self-sufficient food production is one of the highest challenges facing many countries world today, particularly Nigeria, with its rapidly increasing population. Escalating food prices and widespread availability of imported foods in Nigeria seem to suggest that this challenge is not being effectively tackled. Incidentally, food supply in the country depends largely on road transport distribution; hence, a wide variety of Nigerian food would be unavailable without good road networks.

The need to address poverty in Nigeria has been an issue of concern and various intervention programmes have been considered to address widespread poverty in the country, especially among rural populace. People in the rural areas, who are mostly farmers, are often isolated and/or disconnected from profitable economic activities due to nonexistent or inefficient transport infrastructure.

Jacoby (2000) has linked the asset value of poor farm areas to long distances to agricultural markets and maintained that improvement in road transport infrastructure implies capital gains for poor farmers. In sub-Saharan Africa, road transport is the predominant mode and is essential for sustainable agricultural production. Moreover, transport is the means of mobility, for carrying goods and persons from one place to another. In the case of agriculture, it is a means for moving farm produce from the point of production to that of sale, among others.

One of the major objectives of the government in setting up the Directorate of Food, Roads, and Rural Infrastructure (DIFRRI) programme in the late 1980s was to achieve reasonable reduction in the level of poverty in the country, especially among rural dwellers. DIFRRI was to achieve this through improvement in road transport infrastructure, with a campaign to construct about 60,000 kilometres of new rural roads (Brennan, 2011). However, the efficiency and effectiveness of the programme remained an empirical issue.

Table 1: Federal Road Network, Agricultural output and Poverty Level

Year	*Poverty Level (%)(1$per day)*	*Federal Road Network FRDNTW(K)*	*Agricultural output in Millions*
1986	46.0	19516.00	72,135.23
1993	48.7	32179.86	90,596.51
2004	54.4	34340.95	216,208.47
2010	69	34855.61	333,633.53
2011	70	35723.00	350,538.36

Sources: CBN (2012), NBS (1980-2012) and WDI (2012)

Although, as evidence in Table 1, agricultural output showed an upward trend, the upward movement cannot be said to have been enhanced by road transport infrastructural development without proper empirical investigation. Indeed, one primary objective of the government is to achieve a reasonable level of standard of living for the populace through an improvement in the agricultural sector. But there is no evidence, in view of the data in Table 1, to conclude that this was achieved for the country. Hence, one wonders if the increase in agricultural outputs translated into economic development by increasing the level of road transport infrastructure and per capital income—to bring about poverty reduction. However, instead of a reduction in poverty level, the reverse was the case. Therefore, there is the need to investigate if the growth in agricultural output cannot sufficiently bring about adequate food supply and per capita income increase, towards overcoming poverty in Nigeria.

Studies have been carried out in this aspect; but the interactive relationship that exists among these variables seems to be scarce. For instance, Kasali, Ayanwale, Idowu and Williams (2012) and Tunde and Adeniyi (2012) examined the effects of road transport infrastructure on the agricultural sector in Nigeria; but their scopes were a few local government areas and states. Thus, it would be inappropriate to make a national economic pronouncement on the basis of their conclusions. These few studies also used expenditure on infrastructure over water, air and land by the study local and state governments. The findings included the fact that high level of corruption in the country impeded their development impact on road transport infrastructure. Real development in infrastructure were found not to have been commensurate with the amounts expended on them.

Calderon and Serven (2008) and Sahoo et al. (2009) have argued that stock of physical infrastructure is more reliable than the investment in infrastructure when considering the empirical implications of infrastructural development in economic development. This is because in time-series context, simultaneity seems more problematic for studies using investment flows (or their cumulated values) to measure infrastructure than those using physical asset stocks. Therefore, Kasali et al. (2012) and Tunde and Adeniyi (2012) may not have shown the true picture of the transport infrastructure-economic development nexus in Nigeria, since the data employed were not true proxy for transport infrastructural development.

Therefore, the intention of this research is to investigate the interactive relationship that exists among road transport infrastructural development, agricultural output and poverty level. The focus would be on the effects of road transport infrastructural development on agricultural sector and how this could serve as a guide for policymakers in improving the transport sector and, thereby, increasing agricultural productivity and reducing poverty in Nigeria. Specifically, the study seeks answers to the following:

a. What are the interactive effects among road transport infrastructure, agricultural output and poverty level in Nigeria?
b. Is there any existing causal relationship among road transport infrastructural development, agricultural output and poverty reduction in Nigeria?

The study objectives are to: analyse the interactive effects among road transport infrastructure, agricultural output and poverty level in Nigeria; and investigate the existence and direction of causality among road transport infrastructural development, agricultural output and poverty level in Nigeria.

Literature Review

Theoretically, considerable attention has been devoted to roads because of the perception that they will ineluctably lead to poverty reduction and income generation, especially in rural areas. With regard to this, theoretical literature examined the concept from microeconomic and macroeconomic models.

Microeconomic models determine gross prosperity by adding up consumer's surplus, producer's surplus and production costs. The effect of transport infrastructure on economic growth is one piece of evidence emerging from recent studies that have applied duality theory to analyse the productivity effect of highway infrastructure using a cost function (e.g. Seitz, 1993; Seitz and Licht, 1995; Nadiri and Mamuneas, 1998; Cohen and Paul, 2004) or a profit function (Deno, 1988). In the cost function studies, it is assumed that firms are price takers, and that the cost function represents the cost minimising behaviour of such firms with respect to their combination of inputs (i.e. labour, private capital and materials) in producing a given level of output with a given level of technology. The stock of highways is considered a fixed and free input that influences production technology. More highway infrastructure could enhance production possibilities, resulting in cost-minimising firms adjusting their demand and use of inputs, given input prices and the existing output level. Cohen and Paul (2004) focused on the short-run effect of highway investments on manufacturing production by treating private capital and highway infrastructure as quasi-fixed factors. In addition, they presented an extension of earlier studies by measuring the extent and significance of spatial spillover effects of highway infrastructural investment.

On the other hand, macroeconomists have concentrated largely on endogenous growth theory, viewing that the provision of transport infrastructure could affect economic growth either through its direct contribution as a factor input in the production process or through improving technological innovation (Meade, 1952; Aschauer, 1989; and Hulten and Schwab, 1993). The arguments so far are related to impacts on the level of economic activity. The final set of arguments relates to possible impacts on the rate of economic growth. This involves the introduction of arguments from the endogenous growth literature which suggest that certain changes will lead to a continuing increase in the rate of growth in the economy, rather than a shock to the system which shifts the level upward but ultimately leads to a return to an exogenous growth, given underlying rate of growth. Baldwin (1989) suggested that there could be substantial additional 'growth dividend' from the single market, as any initial gain in income could be reinvested and efficiency gains could lead to a lower incremental capital-to-output ratio (ICOR) and an increasing growth rate of the capital stock.

Empirical review

Kassali et al. (2012) examined the effects of rural transport system on agricultural productivity in Oyo State, employing descriptive statistics, Herfindhal Index and Technical Efficiency Approach to analyse the data obtained from a random sample using Intermediary Mode of Transport (IMT), such as bicycles, motorcycles, boats and canoes. The results showed that IMT negatively affects farmers' efficiency and the economy at large. They therefore recommended that policymakers should address policy issues involving improvement in farmers' mobility and rural accessibility, so as to enhance farmers' livelihood and reduce rural poverty.

Akanbi, Bamidele and Afolabi (2013) examined the impact of transport infrastructure improvement on economic growth in Nigeria from the period 1981 to

2011. Using the Ordinary Least Square Regression (OLS) technique, they used the generalized Cobb-Douglas production and extended the neoclassical growth model to include transport infrastructure stock (ie, output of transport sector) along with capital stock (ie, investment on transport infrastructure) as the inputs and gross domestic product. The study found that transport output and investment made on transport infrastructure in Nigeria had significant positive contribution to growth, and that each impact was strong and statistically significant.

Ighodaro (2009) investigated transport infrastructure and economic growth in Nigeria. The study employed granger causality test and VECM and found no causality between road development and economic growth in the country. The contribution of transport to total gross domestic product was on a downward trend, in spite of the fact that 20% of annual budget was put on road projects at both state and federal levels. There was indirect causality via capital stock. The long run part of the VECM estimation showed that the lag value of road development variable was highly significant in the determination of economic growth. The short-run dynamics of growth rate of the economy revealed that the error correction term of road development variables, as well as its lag values were not significant in determining economic growth in Nigeria.

Tunde and Adeniyi (2012) analysed the impact of road transport on agricultural development in Ilorin East LGA of Kwara State. It employed both primary and secondary data; and used simple random to achieve a sample of one hundred and fifty (150) farmers in the study area. Questionnaire and focus group discussion were used to obtain information on the impact of road transport on rural development as a whole, while descriptive and statistical methods were employed for data analysis. The study found that road transport had both positive and negative impacts on agricultural development in the study area. However, the bad condition of the roads affected cost of transport of agricultural produce, which in turn affected the incomes of rural farmers.

Ajiboye (2009) investigated the effects of transport system on food marketing and security in Nigeria. A total of 300 respondents were randomly selected and interviewed, representing 20% of the registered food traders within the study area. The data analysis was based on simple statistics and supported by a series of tables showing percentage distributions of some variables. He concluded that inadequate transport facilities, high cost of transport and high level of wastage due to poor storage and processing facilities highly affected the level of food marketing and security in the study area**.**

Inoni and Omotor (2009) examined the effect of road infrastructural development on agricultural output and income of rural households in Delta State, Nigeria, using household agricultural production and income data from 288 rural dwellers. The results indicated that rural roads had a significant positive effect on agricultural output, reduced transport cost, stimulated demand for rural labour and improved rural income. The road quality instigated a strong positive response on output and income, as a 10% improvement in road quality caused 12% and 2.2% increases in agricultural output and total household income, respectively. Furthermore, road infrastructure promoted inter-sectoral linkages between agricultural and non-farm sectors, which enhanced income diversification strategies among rural households.

Obayelu, Olarewaju and Oyelami (2014) examined the effect of rural infrastructures on profitability and productivity of cassava-based farms in Odogbolu Local Government Area of Ogun State, Nigeria. The study was based on a cross-sectional survey of 120 cassava farmers selected with a multistage random sampling technique from 10 villages. Descriptive statistics were used to generate the composite rural infrastructure index. The results revealed that 5 of the 10 sampled villages were underdeveloped; also, the economic efficiency of developed and underdeveloped areas showed that farmers in the developed areas were better than their counterparts in underdeveloped areas. Farm size, years of farming experience and infrastructural development index (INF) were statistically significant with negative influence on productivity of cassava-based farmers. The significance and indirect relationship of the years of farming experience and infrastructural development index at $p<0.05$ and farm size ($p<0.01$) implied that these variables decreased the total factor of productivity (TFP). Similarly, the coefficient of INF (-0.742 at $p<0.05$) meant that the underdevelopment of infrastructural facilities in the study area was capable of jeopardizing efforts at improving the productivity of cassava-based farmers. Therefore, farmer in the developed areas could generally produce more at lower cost if there were an improvement in infrastructural facilities in the study area.

Kiprono and Matsumoto (2014) studied the effects of infrastructural improvement on agricultural input use, farm productivity and market participation in Kenya. Using longitudinal survey data on smallholder households and corresponding road maps of Geographic Information System (GIS), the researchers estimated the impact of change in road access, from 2004 to 2012, on the change of technology adoption, fertilizer intensification, maize productivity and market participation. The results showed that the use of maize hybrid seeds, chemical fertilizers, maize productivity and milk market participation increased significantly in areas with better road access improvement. There was, however, no evidence to support that improvement in road infrastructure led to a corresponding increase in maize market participation. But the overall results showed that even though there was widespread road improvement, the impact was experienced more in areas with hitherto poorer road access. Thus, investment in such infrastructure led to productivity enhancement in such remote areas.

Usman (2014) analysed the condition of rural road transport in Kwara State, Nigeria, using an integrated approach, whereby rural road transport was viewed as a complex of available roads, transport services and Intermediate Means of Transport (IMT). The data collected were analysed using frequency counts, percentages, mean ranking and histograms. This study also used participatory rural appraisal technique, in which the respondents identified the types and magnitude of transport challenges they encountered. Four topological measures were used to determine the road network connectivity in the sampled LGAs. Overall, road network connectivity, level of road access and transport services were generally poor and inadequate in the rural areas of the state. However, spatial variations were found to exist in the areas. Kaiama LGA had the least road access, road network connectivity and poorest transport services among the sampled LGAs; hence, there was greater restriction on mobility, with attendant negative effects on the economy and general wellbeing of the people in that area. Generally, the transport problems faced by the respondents included poor road surface conditions, high cost of transport, and incessant highway robbery.

Fakayode, Omotesho, Tsoho and Ajayi (2008) conducted an economic survey of rural infrastructures and agricultural productivity in Nigeria. The study examined empirically the place of infrastructures in the agricultural productivity of farm households, using farm level data from Ekiti State, Nigeria. It surveyed eight infrastructures: roads, health centres, market centres, water supply, electricity supply, banks, communication gadgets, and education, as well as their influence agricultural productivity. The data were gathered from one hundred farm households and fifteen discussant groups selected across the study area. The data were analysed using Total Factor Productivity (TFP) and Ordinary Least Squares (OLS) regression analysis. The results indicated that three significant variables (land, fertilizer and the infrastructure index) were key determinants of agricultural productivity in the study area.

Felloni, Wahl, Gilbert and Wandschneider (2001) studied infrastructure and agricultural production in China. The study used cross-sectional data from 83 states and 30 provinces to assess the effect of transport infrastructure and electricity on agricultural production. Evidence from both datasets suggested that the density of roads and availability of electricity were significant predictors of production and productivity in agriculture. The results also suggested that access to transport infrastructure and electricity are crucial to the modernization of Chinese agriculture.

Gollin and Rogerson (2010) studied agriculture, road and economic development in Uganda. The static general equilibrium model was used to explore the relationships between high transport costs, low productivity, and size of the quasi-subsistence sector. They parameterized the model to replicate some key features of the data and then performed a series of quantitative experiments. The results suggested that the population in quasi-subsistence agriculture was highly sensitive to both agricultural productivity levels and transport costs. The model also suggested positive complementarities between improvements in agricultural productivity and transport.

Onikosi-Alliyu (2012) studied transport infrastructure and economic growth in Nigeria over the period of 1970-2010 using granger causality test. The results showed that both instantaneous and past values of transport infrastructure have explanatory power on economic growth in Nigeria, while the opposite could not be established. The instantaneous causality test between infrastructure and economic growth showed that transport infrastructure caused economic growth instantaneously. Therefore, it concluded that transport infrastructure instantaneously causes economic growth in Nigeria. This reiterated the fact that no economic growth can be without supportive transport infrastructure in the country.

Joyce (2008) examined the trend of transport investment and analysed the effects of transport investment on regional economic development in China, using two stage least-squares (2SLS method). The result showed that transport investment had positive and statistically significant effect on GDP, and that those provinces that had invested more in transport infrastructure had greater outputs.

Adedeji, Olafiaji, Omole, Olanibi and Yusuff (2010) surveyed the impact of road transport on rural development in Obokun Local Government Area of Oyo State, using both primary and secondary data. The analysis of data revealed an inequality in the provision of road infrastructure and rehabilitation in the area, resulting in disparities in level of development. The poor condition of roads had negative effects on agricultural activities, which were the major sources of income for the respondents. The results showed that development was concentrated in major towns in the study area, while rural communities seemed abandoned. To correct the anomalies and ensure sustainable development, the researchers recommended the need for integrated development strategy, in line with Shiru's (2008) assertion, to develop all sectors of the rural economy and link them up with their urban counterparts without a sense of backwardness. Such a strategy promotes spatial, social, economic and psychological linkages among the various sectors.

Njoku and Ikeji (2013) studied the impact of quality transport infrastructure on the Nigerian economy. Budgetary allocation to transport and the contribution of the transport sector to gross domestic product (GDP) were used for the computation of estimates. Pearson Correlation Coefficient was used in testing the hypothesis that stated that 'the contribution of the transport sector to the economy did not increase with investment in transport infrastructure'. The result was positive and significant; hence, the transport sector's contribution to the economy increased with investment in transport infrastructure. The second hypothesis, that 'there was no significant contribution to the GDP by the transport sector,' was analysed using variance with multiple regressions. The result showed a significant R value of 0.98 and R^2 of 0.97 respectively. Therefore, the alternative hypothesis which stated that there was significant contribution to the GDP by the transport sector was accepted. Insufficient funding was identified as the bane of the sector. The study suggested that policymakers should prioritize appropriate and adequate investment in transport infrastructure towards building a viable economy.

Keho (2011) examined the temporal relationship between transport infrastructure investment and output in Cote d'Ivoire over the period 1970-2002. Using cointegration and causality tests within a multivariate framework, it was found that the public investment in transport infrastructure, private investment and economic output were cointegrated. The Granger causality tests revealed that public investment in transport did not have a causal impact on economic growth; conversely, economic growth had a causal impact on transport investment.

Adepoju and Salman (2013) studied 'increasing agricultural productivity through rural infrastructure: evidence from Oyo and Osun states, Nigeria'. Using multistage sampling procedure, data were collected through the use of structured questionnaire administered on one hundred and sixty respondents; these were analysed using descriptive statistics and total factor productivity model to explain the effects of the available infrastructure on farmers' productivity. The findings on socioeconomic characteristics of the respondents revealed that 92.9 and 86.3 percent of the respondents were male for Surulere and Ife East LGAs, respectively. Above 56 percent of the respondents were in the age range of 41-50 years and had household sizes that were between 6 and 8, respectively, in the LGAs. Majority of the respondents had formal education and took farming as primary occupation. The model used revealed that farm size and labour positively and significantly affected productivity at 5% and 1% levels, respectively. It was, however, observed that the contribution of female labour in Ife East LGA was higher than that of male, thus introducing gender productivity differential into the production process. With regard to the infrastructural elements, improvement in soil practices and extension visits had positive and significant (5%) effects on productivity in both LGAs. It was recommended that more infrastructure be provided to further improve agricultural productivity of rural farmers.

Alder (2014) used general equilibrium framework, as used in Eaton and Kortum (2002), to estimate the contribution of transport infrastructure to regional development in India. He first analysed the developmental effects of a recent Indian highway project that improved connections between the four largest economic centres, and then estimated the effect of this new infrastructure on income across districts, using satellite data on night lights. The results showed aggregate net gains from the Indian highway project, but unequal effects across regions. China had followed a different highway construction strategy and experienced more significant convergence across regions than India. The researcher therefore used the model to gauge the effects of a counterfactual highway network for India that replicated the Chinese strategy of connecting intermediate-sized cities and found that the counterfactual network benefited the lagging regions of India, but not the aggregate economy. The study also constructed additional counterfactuals and discussed their effects on economic development. The findings suggested that recent Indian highway investments led to positive aggregate net gains, but unequal effects across districts.

Methodology

This section describes the methodology adopted in modelling the relationship among transport infrastructural development, agricultural output and poverty level. It also includes the theoretical framework of the study, sources of data, definitions and measurement of variables in the model, as well as estimation techniques.

Theoretical framework

This study is built on the theoretical framework of Lakshmanan (2007) within the framework of growth theory; however, it relies more on the industrial location theory. Locational analysis emphasises the importance of interaction between transport costs, on the one hand, and market size and economies of scale, on the other. With well-developed transport infrastructure, agricultural output gains a larger market area and dominance, which in turn promotes concentration of other firms in the same location. This invariably enhances job opportunities for the people in this area, which directly or indirectly reduces the poverty level of an economy.

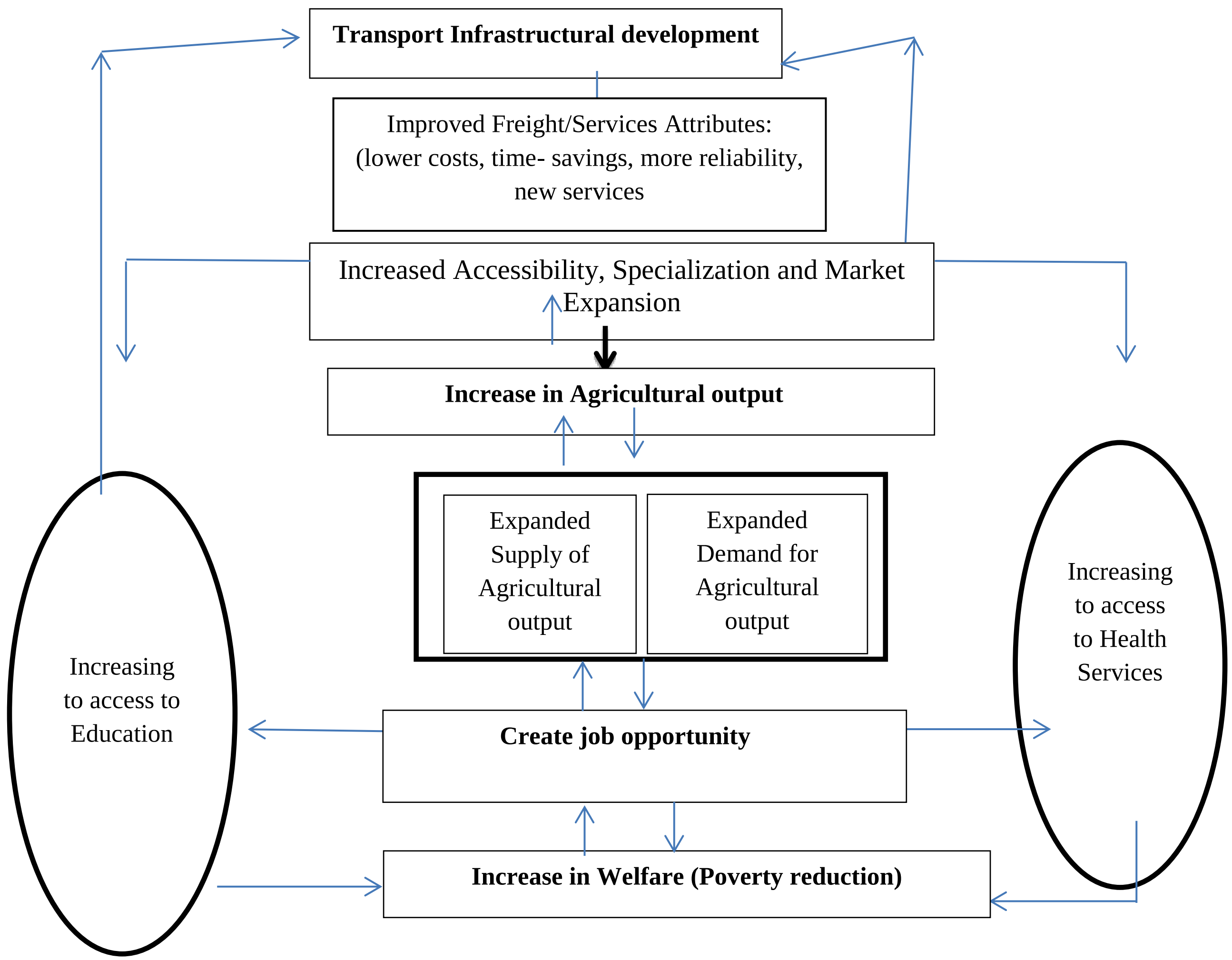
Figure 1 offers the mechanisms and processes underlying the wider economic benefits of transport infrastructural investments. It is a contemporary version of what Williamson (1974) and O'Brien (1983) called 'forward linkages' of transport infrastructure. Better transport systems, for instance, support effective movement of goods and workers. It can also increase a firm's productivity by lowering the transport costs of inputs and outputs. Moreover, productivity gains may come from a reduction in other business costs. For example, good quality roads could lead to savings on vehicle maintenance costs; increase in the reliability of transport allows farmers to reduce stock inventory costs. In some circumstances, transport improvements help improve access to customers or remove trade barriers, encouraging farmers to exploit economies of scale by serving larger markets. This will, in a long-run, result in a reduction in the average costs of such farms, which can be translated into increase in productivity. Therefore, one way in which transport infrastructural investment influences farm productivity is the quick access to the market.

Furthermore, overall productivity growth may arise because transport infrastructure investment can be directly responsible for augmenting the productivity of labour. For example, exhausted workers may be less productive if they have to spend more time commuting. Thus, improvements in transport services can have a direct impact on labour productivity by lowering commuting time to and from work (Prud'homme and Lee, 1999; SACTRA, 1999; OECD, 2002).
Lower cost and increased accessibility due to transport improvements modify the marginal costs of transport producers, households' mobility and demand for goods and services. Such changes ripple through the market mechanisms, endogenizing employment, output, and income in the short-run.

In addition, overall productivity growth in agriculture may arise because transport infrastructural development is directly responsible for augmenting the productivity of labour. For example, workers may be exhausted and, therefore, less productive if they have to spend several hours commuting. Thus, improvements in transport services can have direct impact on labour productivity by lowering commuting time to and from work (OECD, 2002). Similarly, an increase in labour productivity can result from a better match between the supply of jobs and skilled workers. The underlying reason for this is that transport investments can lead to an increase in labour supply by attracting immigration of households and improve job accessibility. With more choices of prospective employees, firms will have more opportunities to recruit those who have working experience and appropriate skills; hence, investments in transport infrastructure can enhance the overall productivity of firms. This could lead to changes in the quantities of inputs of production, on the one hand, and to poverty reduction and economic growth, on the other.

Figure 1: Theoretical Nexus between Transport infrastructural development and sectoral output growth

Source: Adapted from Lakshmanan (2007)



Transport infrastructure improvements may lead to a rise in consumption pattern and labour demand. This suggests that the net employment effect is ambiguous. The primary reason for this is twofold. First, the overall cost reduction associated with increased productivity enables firms to expand their markets. One specific example would be the case of competition in goods markets. That is, firms experiencing productivity gains could lower the prices of their products in order to increase their market share. Falling relative prices would stimulate the demand for the outputs of these firms, thus increasing the demand for workers and an increase in the welfare of people. This impact on the demand for labour depends on the price elasticity of product demanded (Button, 1998; Lakshmanan et al., 2001). If it is high, then one may anticipate a large increase in output and potentially in employment. A higher productivity environment could be attractive to investment.

Transport infrastructural development that enhances a region's productivity and competitive position may thus encourage expansion of existing businesses and attract private inward investment to enter the region. This could increase overall production and demand for employment. When transport costs, associated with transport infrastructural development, remove trade barriers and allow export of products to other regions, they affect employment in interregional trade competition (Button, 1998; Rietveld and Bruinsma, 1998; Rietveld and Nijkamp, 2000). As an increase in the demand for employment is anticipated from those expanding their markets geographically, poverty reduction in the region becomes realizable.

Moreover, when living standards of people increase over time, there is increase in aggregate demand for goods and services, access to health services, expansion of knowledge through access to education and increase in quality of labour supply. The subsequent effect from this is the revenue generated by the government as a result of market expansion. As fiscal revenue increases through growth, additional budget can be generated for programmes that improve the living conditions of the poo, such as the provision of more transport infrastructure.

Model specification

A way to summarize the dynamics of macroeconomic data is to make use of vector autoregression. VAR models have become increasingly popular in recent decades. They are estimated to provide empirical evidence on the response of macroeconomic variables to various exogenous impulses in order to discriminate between alternative theoretical models of the economy. This simple framework provides a systematic way to capture rich dynamics in multiple time series, and the statistical toolkit that came with VARs was easy to use and interpret. As Sims (1980) and others argued in a series of studies, VARs held out the promise of providing a coherent and credible approach to data description, forecasting, structural inference and policy analysis.

With vector autoregressive models, it is possible to approximate the actual process by arbitrarily choosing lagged variables. Thus, one can transform economic variables into a time series model without an explicit theoretical idea of the dynamic relations. A VAR is an n-equation, n-variable model in which each variable is in turn explained by its own lagged values, plus current and past values of the remaining n-1 variables. A VAR can be thought of as the reduced form of a dynamic economic system involving a vector of variables Z_t, that is, starting from the so-called structural form.

$$Az_t = B_1 z_{t-1} + B_2 z_{t-2} + ... + B_p z_{t-p} + u_t \text{...}2$$

$$Euu' = \Sigma u = \begin{bmatrix} \delta^2_{u1} & 0 & 0 \\ 0 & \delta^2_{u2} & 0 \\ 0 & 0 & \delta^2_{un} \end{bmatrix} \text{...}3$$

A VAR of lag length p (V AR(p)) can be written as:

$$z_t = A^{-1}B_1 z_{t-1} + A^{-1}B_2 z_{t-2} + ...A^{-1}B_p z_{t-p} + A^{-1}u_t \text{..................................}4$$

Where $E(u_t) = 0, E(u_t u'_T) = Eu$ for $t = T$ and 0 otherwise. Thus, a vector autoregression is a system in which each variable is expressed as a function of own lags as well as lags of each of the other variables. VAR's come in three varieties: reduced form, recursive and structural. In each case, what we want to solve is the identification problem. That is, our goal is to recover estimates of *A, B and* Σu .

Each variable is expressed as a linear function of its own past values and past values of all other variables. Each equation is estimated by OLS. The error terms are the surprise movements in the variables, after taking past values into account. If the variables are correlated with each other, the error terms will also be correlated.
In practice, given the structural form, we estimate $A^{-1}B_1, ...A^{-1}B_p$ and $A^{-1}\Sigma u, ...A^{-1,}$ but we cannot easily revert to the *A's* and the Σu that are our object of interest.

Measurement and definitions of variables

ag is agricultural output, which is measured by the sum of crop production, livestock, forestry and fishing products.

tr represents road transport infrastructural development in Nigeria, proxy by the length of paved federal road in kilometres as data constraint restricts to segregate the transport capital figures from the country's total investment (*k*). This has been used in many studies (cf. Canning, 1999; Canning and Bennethan, 2000; Faridi et al., 2011; Huang and Harata, 2010; Boopen, 2006; Calderon and Serven, 2008a; Sahoo et al., 2009; Oladipo, 2014).

pt represents poverty rate in Nigeria, proxy by real consumption expenditure per capita (RCX). Real consumption expenditure per capital is used as measure of poverty. Though an alternative to this measure is per capita income, this study employed real consumption expenditure per capita on the basis of the consensus that an expenditure measure of poverty is superior to income measures (Okojie, 2002; Ogun, 2010; Oladipo, 2014).

Sources of data

This study used essentially secondary data for analysis. The data on road transport network, agricultural output and industrial output from 1980 to 2014 were sourced from the Central Bank of Nigeria's (CBN) statistical bulletin (2015) and various publication of the National Bureau of Statistics (NBS).

Estimation techniques

Given the specific objectives of this study, statistical and econometric techniques of data analysis were employed. The first objective, which is to examine the interactive effects between transport infrastructural development and sectoral output level (manufacturing and agricultural outputs), was achieved, given the VAR as an *n* equation, *n* variable model in which each variable is in turn explained by its own lagged values, plus current and past values of the remaining *n-1* variables. A VAR can be thought of as the reduced form of a dynamic economic system involving a vector of variables z_t.

$$Az_t = b_1 z_{t-1} + b_2 z_{t-2} + \dots + b_p z_{t-p} + u_t \quad \dots 5$$

$$z_t = (ag_t\, pt_t\, tr_t) \text{ and } u_t = \sum e_t$$

Where $b_1, b_2 \dots b_p$ are the coefficients of road transport infrastructural development, agricultural output and manufacturing output. Therefore, z_t can be expressed as:

$$ag_t = b_1 ag_{t-1} + b_2 pt_{t-1} + b_3 tr_{t-1} + e_{1t} \quad \dots 6$$

$$pt_t = b_4 pt_{t-1} + b_5 g_{t-1} + b_6 tr_{t-1} + e_{2t} \quad \dots 7$$

$$tr_t = b_7 tr_{t-1} + b_8 ag_{t-1} + b_9 pt_{t-1} + e_{3t} \quad \text{……………………………………}8$$

Where

$b(s)$ 1 to 9 are the coefficients of the endogenous variables

Therefore, to obtain the interactive effect among road transport infrastructural development agricultural output and poverty level, the impulse response functions (IRFs) are employed, given equations 6 to 8. Impulse responses trace out the response of current and future values of each of the variables to a one-unit increase (or to a one-standard deviation increase, when the scale matters) in the current value of one of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero. The study observed that if *A* and Σu are known, then:

$$z_t = A^{-1}Bz_{t-1} + A^{-1}u_t \quad \text{…………………………………………………………}9$$

The IRFs to a unit shock of u can be calculated if A^{-1} is known and the system has been in steady state for a while. In tracing the dynamics to a shock to the first variable in the VAR model, when a shock hits at time 0, then:

$$u_0 = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} \quad \text{…………………………………………..…………………………………}10$$

$$z_0 = \begin{bmatrix} tr \\ ag \\ pt \end{bmatrix} = A^{-1}u_0 \quad \text{…………………………………..……..…………………………}11$$

For every *s > 0*;

$$z_s = A^{-1}Bz_{s-1}$$

To summarize, the impulse response function is a practical way of representing the behaviour over time of z in response to shocks to the vector u.

On the other hand, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

$$G(L)z_t = u_t \quad \text{……………………………………………………………………12}$$

The VMA (vector moving average) representation of our VAR is:

$$z_t = \Gamma_0 u_t + \Gamma_1 u_{t-1} + \Gamma_2 u_{t-2} + ... \quad \text{………………………………………………13}$$

And the error in forecasting z_t in the future is for each horizon *s*:

$$z_{t+s} - \mathrm{E}_t z_{t+s} = \Gamma_0 u_{t+s} + \Gamma_1 u_{t+s-1} + \Gamma_2 u_{t+s-2} + ... + \Gamma_{s-1} u_{t+1} \quad \text{……………………14}$$

From which the variance of the forecasting error is:

$$Var(z_{t+s} - E_t z_{t+s}) = \Gamma_0 \Sigma u \Gamma'_0 + \Gamma_1 \Sigma u \Gamma'_1 + \Gamma_2 \Sigma u \Gamma'_2 ...... + \Gamma_{s-1} \Sigma u \Gamma'_{s-1} \quad \text{……….15}$$

On the basis of this formula, we can compute the share of the total variance of the forecast error for each variable attributable to the variance of each shock.

Moreover, as the substantial data used in the study are macroeconomic data, there was the need to first examine the characteristics of the data to ensure their validity for further econometric application. In this context, Augmented Dickey-Fuller (ADF) (1979) and Phillips-Perron (PP) (1988) tests were employed in order to determine the integrated level of each series. The ADF test was performed using the equation:

$$\Delta X_t = \alpha + \varphi T + (1-\beta) X_{t-1} + \sum_{j=1}^{n} \lambda_i \Delta X_{t-j} + \varepsilon_t \quad \text{……………………………………………………………16}$$

Where

Xt is the variables that was tested for unit root

Δ is the first difference operator

α is the constant term

t is a time trend

n is the lag number

The null hypothesis is H0 ((1-β) = 0, β=1), implying the non-stationary of *Xt*. Rejecting the null hypothesis shows that *Xt* has no unit root. Lag length is selected by minimizing AIC. Also, whether residuals are white noise was taken into consideration in selecting proper lag length. Rejecting null hypothesis requires that the calculated test value is greater than critical values calculated from MacKinnon (1991). This was reconfirmed by performing Philip Perron test and relying on the ADF equation without non-augmented form ($\Delta Xt\text{-}j$, j=1, 2… are not included in the DF equation).

The application of vector autoregressive was employed were the series were stationary at level i.e. I(0). However, where the series were integrated of order one, i.e. I(1), Johansen's procedure was used to determine whether any cointegration vector existed among the variables. After applying cointegration test, where the variables were stationary at first difference and also cointegrated, the Vector Error Correction Model was appropriately used to investigate the existing relationship. Where the variables were I(1) but not cointegrated, the Error Correction Model was applied; but where the series integrated different orders, for example where I(0) and I(1), it was not possible to investigate the interactive effect via Error Correction Model. In this situation, the one way to determine the interactive effect relationship between series is the use of Ordinary Least Square method by specifying the variables in their level of stationarity.

Empirical Results

Unit root test for annual data series

Table 2 presents the results of unit root tests using Augmented Dickey Fuller test applied on annual data series.

Table 2: The result of unit root test using Augmented Dickey Fuller test

Series	*Level*	*First Diff*	*Remark*
Lpt	-1.25	-5.45	I(1)
Ltr	-1.66	-6.11	I(1)
Lag	-1.52	-3.89	I(1)

Source: Author's computation

Note: at 5 percent critical value = -2.96. Lag, Ltr and Lptare log (of agricultural output, road transport infrastructural development, poverty level.)

Evidence from the data in Table 2 confirmed that all the variables (agricultural output (ag), road transport infrastructural development (rt) and poverty rate (pt)) were not stationary at the given level. However, they became stationary after first difference. Since the series were integrated of order one, i.e. I(1), the presence of significant cointegration relationship among the variables could be determined.

Although the results of the unit root test showed that all the variables were in random processes, the variables could not express long-run convergence or long-run equilibrium. The stationarity of the residuals suggests that there is evidence of convergence to long-run equilibrium among the integrated variables. To ascertain whether there was cointegration among the variables, optimal lag length of variables was determined (Table 3). The Akaike Criterion (AC), Schwarz Bayesian Criterion (SBC) and Hannan-Quinn criterion (HQC) were used to indicate the optimal lag structure for the VAR upon which the cointegration analysis was based on.

Table 3: Determination of optimal lag length

	LogL	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	-76.5094	NA	0.151419	6.625783	6.77304	6.66485
1	-19.0115	95.82981	0.002685	2.584292	3.173319	2.740561
2	-2.15276	23.88322*	0.001456*	1.929397*	2.960194*	2.202868*
3	2.047366	4.900149	0.002424	2.329386	3.801953	2.720059

*indicates lag order selected by the criterion at 5 percent level of significance.

The cointegration test was carried out using Johansen cointegration test with lag 2. This is because Johansen cointegration is a superior test that lies on asymptotic property and is sensitive to error in small samples. It is also robust to many departures from normality, as it gives room for normalization with respect to variables in models that automatically become dependent variables. This result is presented in Table 4.

Table 4: Cointegration test

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Critical Value*	*Prob.***
None *	0.386859	19.78281	29.79707	0.4376
At most 1	0.167967	8.042964	15.49471	0.4608
At most 2	0.140358	3.629756	3.841466	0.0568

Trace and Max-Eigenvalue indicates no cointegrating eqn(s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level of sg

The results of the cointegration test in Table 4 confirmed that there is no cointegration relationship among the macroeconomic variables in the model. But the study proceeded in obtaining the interactive effects among agricultural output (ag), road transport infrastructural development (rt) and poverty rate (pt), using impulse response approach by estimating the VAR models stated in equations 6-8 by applying the VECM techniques. Moreover, the pair-wise granger causality test was appropriately used to investigate the causal relationship among the series.

Results of VECM Impulse Response Analysis

One standard deviation in the model in Figure 1 was calculated in percentage. For each of the variables, the horizontal axis of IRF showed the number of periods that had passed after the impulse was given, while the vertical axis measured the responses of the variables. Evidently, Figure 1 (panel b and c) showed that one percent innovation in both road agricultural output and poverty reduction brought about a neutral response by road transport development at the initial period, but became positive over time. In panel d, agricultural output increased from 0.22 percent from the initial period to 0.23, 0.26, 0.27 and 0.28 percent in the tenth, fifteen, twentieth and twenty-fifth period, respectively, as a result of an innovation in road transport infrastructure. This was in contrary to the response of agricultural output as a result of an innovation in real consumption expenditure per capita, which was used in capturing poverty level in panel f.

From panel g, a shock to road transport infrastructural development produced a continuous increasing positive response by real consumption expenditure per capita—for instance, 0.19 percent was produced at the initial period and it increased to 0.43, 0.61, 0.69, 0.73 and 0.74 percent in the fifth, tenth, fifteenth, twentieth and twenty-fifth period, respectively. Moreover, a negative response of 0.014 was observed by real consumption expenditure per capita as a result of an innovation in agricultural output at the initial period and this negative response continued throughout the period, as observed in panel h.

Tables 5 (i-iii): VECM Forecast Error Variance Decomposition

Table 5(i,): Variance decomposition of log (tr)

Period	*S.E.*	*LOG(TR)*	*LOG(AG)*	*LOG(PT)*
1	0.100847	100	0	0
5	0.198477	96.79856	1.124164	2.077273
10	0.269362	96.97424	1.213407	1.812348
15	0.324726	97.03848	1.211401	1.750122
20	0.371837	97.06737	1.20849	1.724138
25	0.413577	97.08388	1.206692	1.709427

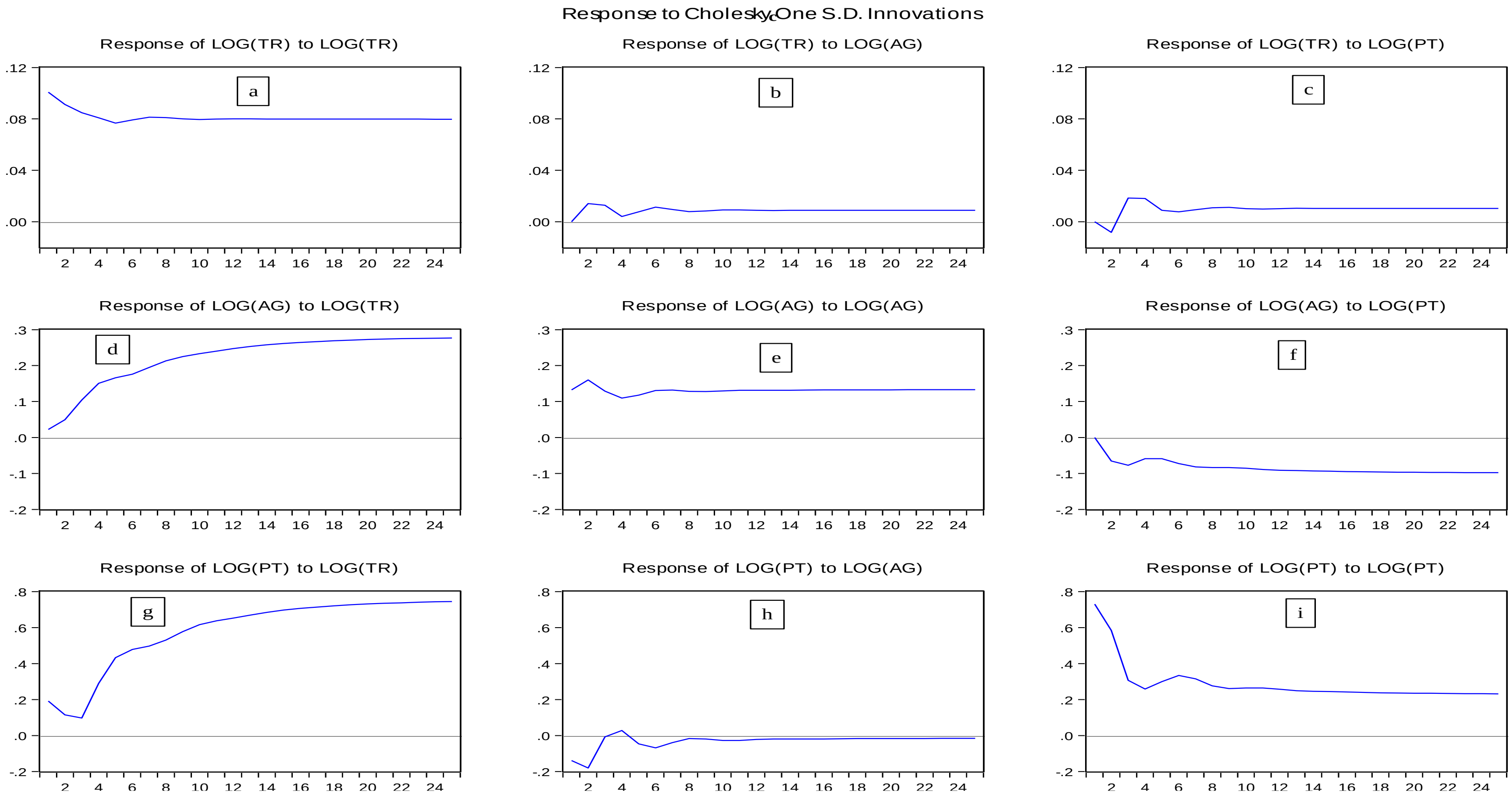


Figure 2: Impulse response functions

Table 5(ii): Variance decomposition of log (ag)

Period	*S.E.*	*LOG(TR)*	*LOG(AG)*	*LOG(PT)*
1	0.134429	2.698224	97.30178	0
5	0.408684	38.31357	51.36465	10.32178
10	0.709562	56.25762	33.71694	10.02544
15	0.97437	63.27021	26.97918	9.75061
20	1.201844	66.60329	23.80544	9.591273
25	1.39992	68.45352	22.05027	9.49621

Table 5(iii): Variance Decomposition of log (pt)

Period	*S.E.*	*LOG(TR)*	*LOG(AG)*	*LOG(PT)*
1	0.767088	6.183921	3.316768	90.49931
5	1.228472	21.86338	3.649389	74.48723
10	1.846316	52.7498	1.84081	45.40939
15	2.44179	67.62865	1.092716	31.27863
20	2.972451	74.93016	0.755368	24.31447
25	3.441582	78.99869	0.574855	20.42646

Source: Author's analysis (2016)

According to Akinlo (2003), while impulse response functions are very useful in ascertaining the direction of the effect of a shock to innovations of a variable, the magnitude of the effect of shock to an innovation can only be deciphered by forecast error variance decompositions. In other words, they show the explanatory contribution of the shock to the innovations of variables. They indicate the proportion of the forecast error in a given variable that is accounted for by innovations in each endogenous variable.

Table 5 (panel i) shows that shocks explained a large proportion of the variations in the variance of road transport infrastructure. But the magnitude, which decreased from a high value of 100 percent to 96.8 percent in the fifth period, later increased marginally over the periods. Other variables that were of importance were agricultural output growth and real consumption expenditure per capita. Although they explained a neutral proportion of variations in the variance of road transport infrastructure at the first period, this increased from 0.00 percent to 1.12 and 1.21 percent (of agricultural output) in the fifth and tenth period before the effect began to fall gradually over time. A neutral effect was also observed at the initial stage by real consumption expenditure per capita, which later increased to 2.07 percent in the fifth and then reducing gradually over time.

Panel (ii) of Table 5(ii) depicts the proportions of forecast error variance in agricultural output, explained by innovations of the considered endogenous variables. The two variables appeared crucial in determining the variation in the variance of agricultural output. The magnitude of road transport infrastructural development, which was 2.69 percent in the first period, increased greatly to 38.31 percent in the fifth period and continued to 68.50 percent at the twenty-fifth period. The innovations in agricultural output and the variation in itself, which were very high at the first period, reduced greatly over time. The former reduced from 97.30 percent in the first period to 51.36%, 33.72%, 27%, 23.80 and 22.05% in the fifth, tenth, fifteenth, twentieth and twenty-fifth periods respectively. The variation in agricultural output as a result of an innovation in real consumption expenditure per capita was neutral in the first period, but it became 10.32 percent in the fifth period and reduced marginally over time.

From Table 5(iii) panel (iii), the innovation in road transport infrastructure made the real consumption expenditure per capita variance to be decomposed by 6.18 percent in the first period but increased sharply to 21.86, 67.62, 74.93 and 79 percent in the fifth, fifteenth, twentieth and twenty-fifth periods, respectively. Moreover, the magnitude of agricultural output reduced from 90.50 percent in the first period to 74.49 percent and further reduced greatly over time.

The data in Table 6 indicate that both road transport infrastructural development and agricultural output granger-cause poverty at 5% level of significance. There was also the existence of causal relationship between agricultural output and poverty level, which ran from agricultural output to poverty reduction, proxied by real consumption expenditure per capita at 5% level of significance. This implies that development in transport sector as a result of improvement in road transport infrastructure could bring about development in agricultural sector, as well as reduction in poverty level through an increase in real consumption expenditure per capita.

Table 6: Causal relationship among road transport infrastructural development, agricultural output and poverty Level

$\alpha_1 = \alpha_2 = 0$	$F - Statistics$	$p - value$	Remark
$\log(TR) \rightarrow \log(AG)$	8.87823	0.0056	Causality
$\log(AG) \rightarrow \log(TR)$	0.63266	0.4324	No causality
$\log(PT) \rightarrow \log(AG)$	2.17496	0.1504	No causality
$\log(AG) \rightarrow \log(PT)$	11.3237	0.0021	Causality
$\log(PT) \rightarrow \log(TR)$	0.07968	0.7796	No causality
$\log(TR) \rightarrow \log(PT)$	4.49488	0.0421	Causality

Source: Author's computation (2016)

5. **Conclusion and Recommendations**

The empirical evidence from the IRFs indicated that improvement in road transport infrastructure reduces poverty through an increase in real consumption expenditure per capita. This was also supported by the causality result. By implication, an attempt to formulate economic policy in improving government expenditure on transport sector could increase people's welfare and, thereby, reduce poverty.

An unexpected observation was the negative response of real consumption expenditure per capita to innovation in agricultural output; although this is contrary to theories, it somehow showed the true picture of Nigerian economy. The growth in agricultural output may be outweighed by population growth rate, real income of consumers as a result of inflation, and even consumption pattern, by the demand for foreign goods at the expense of domestic production. Thus, there was a positive response of agricultural output to innovation in road transport infrastructural development, which implies that when good roads are constructed, there is increased farmers' mobility and access to the market at low cost. This makes agricultural practice more convenient.

This study, therefore, recommends that, for the Nigerian government to succeed in its poverty alleviation objective, it should develop more road networks, especially across the rural areas (where agriculture is the main occupation) to link with urban areas (where farm produce are more valued). Also, the government should invest heavily in federal road maintenance in accordance with global trend and improving economic productivity. Moreover, it should provide financial assistance and a conducive policy environment to make the agricultural sector attractive and lucrative.

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