Telecommunications and Travel Demand: A Confirmatory Study in the Nigeria Case

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Abstract

Understanding the relationship between telecommunications and transportation is a concept fundamental to the development of the country against the set goals and objectives of the nation's economic development strategies. With the recent shift in policy towards a market-based system of resources allocation, increasing attention has been paid to the development of an efficient telecommunication system in the Nigeria. The government's path breaking process of privatizing its infrastructural services especially the telecommunication sector since the late 1990s has lent credence to a new way of life. The growth rate of the telecommunication industry has been much faster than that of either oil or banking industries, suggesting that the telecommunication industry dominates economic activity. This has led to economic growth, making the country the largest telecommunication market in Africa given the spate and degree of mobile telecommunication penetration. However, the relationship between telecommunications applications and transportation generally and on travel demand and some micro-economic variables in the country in particular remain largely un-investigated at the national level. The study seeks to determine whether there is a particular type of relationship that leads to greater investment in telecommunication and subsequent reduction in travel demand considering the relationship among telecommunications demands, travel demand, transportation system infrastructure, travel cost, telecommunications systems infrastructure, telecommunication costs, land use and economic activities and socio-demographic category variables of national time series data extending over a thirty-year period - between 1980 and 2010 using structural equation model. This study supports the complementarity hypothesis. The findings will assist the government, transport planners and other policy makers in determining the different ways to design transportation strategies. It also has wider implications for travel demand in light of the recent withdrawal of fuel subsidy by the government.

Keywords: travel demand, telecommunication demand, infrastructure, structural equation model

1. INTRODUCTION

Many development countries particularly those in the sub-Saharan African countries have been pursuing one form of economic reform or the other in the past two decades with a view to improving their overall economy. The transport sector in particular has been receiving greater attention with a view to ensuring greater economic development of the countries. This is against the backdrop of the importance of strong influence of transportation on economic development since the linkages between transportation provision and economic development is that multiplier effect. Indeed, the economic development and growth of these countries is considered to be dependent on improved provision of transport infrastructure, with the direct effect on trade, employment, large scale production and development of indigenous heavy industries (Haynes and Button, 2001).

In recent times, the possible linkage between transport and economic development points to the fact that transportation ensures interregional spread of economic activities and minimizes the geographical variation in employment, income, migration, and other resultant spatial inequalities in the welfare of the people. In general terms, investment in transport infrastructure and services normally has a significant input in the production process and as well as open up the rural and sub-urban areas of the countries concerned.

Following steadfast and committed process of economic development in the developed countries and the drive to overcome long period of economic decline, weakened institution and inadequate infrastructure, the past decade witnessed noticeable growth of the economies of these countries bringing thereabout, an influence on travel demand. Obviously, there has been increase in incomes levels, rising car ownership, improvement in the transport systems, changes in the demographic and social structure of the households, and more importantly, economic reforms leading to liberalization of the whole economic sector and competition between public and organize private sector. These identified factors contribute to the growth in the travel demand with the public requiring greater mobility to meet its economic, educational and other needs. The changes in economic structure of many of these countries, with particular preference for private-public participation in the provision of infrastructure and economic diversification further contribute to the surge in travel demand.

There are concerns arising from the deleterious effects of the increase in the travel demand. These include road accident, pollution, energy consumption and more importantly, sub-urbanization development and urban sprawl. Meeting the demand for travel especially in the developing counties becomes a challenge in a situation where the institutional capacity is not strong and the existing transport infrastructure and services are unable to support the other sectors of the economy. One of the ways of addressing the surge of travel demand in today's world is the strategy of providing other infrastructure and services that can substitute journeys. Telecommunications lends itself to this approach. The literature abounds with conflicting findings on the beneficial substitutability of information and communication technology for physical travel (Jain and Lyons, 2008; Lyons and Urry 2005; Mokhtarian, 2009; Niles, 1988, 1994; Oyesiku, 1996; Salomon, 1985 and Senbil, 2003).

This is particularly important as the telecommunication sector is growing in importance in developing countries across the world. In the Nigerian case, the growth rate of the telecommunication industry has been much faster than that of either oil or banking industries (Pyramid research, 2010). These facts, which suggest that the telecommunication industry dominates economic activity, leading to economic growth and can influence travel demand in Nigeria is striking. Presently, Nigeria is the largest telecommunication market in Africa given the spate and degree of policy reform in the sector. Nigeria has well over 98 million mobile subscribers with the capacity for further growth (Nigerian Communications Commission, 2012).

With the recent shift in policy towards a market-based system of resources allocation, increasing attention has been paid to the development of an efficient telecommunications in Nigeria and since late 1990s, the government initiated a path breaking process of privatizing its infrastructural services especially the telecommunication sector. In view of this massive investment in telecommunications, understanding the relationship between telecommunications and transportation becomes crucial to the formulation of developmental policies of the country. However, the impact of the investment in and demand for telecommunications on travel demand in particular and macro-economic variables in the country in general remain largely un-investigated in the country. The study therefore seeks to investigate relationship subsisting between the demand for and supply of telecommunications and the need for physical travel or transport in Nigeria.

The rest of the paper is organised as follows: Section two reviews the literature and the theoretical model. In the third section, the methodology is presented followed by the research findings in chapter four. Section 5 concludes the study

2. TELECOMMUNICATIONS AND TRAVEL DEMAND RELATIONSHIP

The positive and significant impact of telecommunication on economic growth and development in Nigeria is largely settled in the literature (Ajiboye et al, 2007; Akanbi & Du Toit, 2010; Awoleye et al., 2012; Gold, 2010; Osotimehin et al, 2012& Tella et al., 2007). However, the objective of the review is the potential effect of telecommunication on travel demand. The work and the studies of Oyesiku (1996), Salomon (1982) and (1986) and Mokhtarin, (1990, 2000, 2002) and Choo and Mokhtarin, (2007) on the relationship between telecommunication and travel demand is adequately reported in literature and therefore, need not be repeated here. Suffice to state, however, are the possible ways that telecommunication can influence travel demand. Seven of such are as shown in Table 1, illustrating the applications of telecommunication to various activities.

Table 1- Application of telecommunications and information technology to various activities

Telecomm/ Technology Measure	Commuting	Business	Service	Shopping	Education	Social Visits	Leisure	Servicing Passenger
Transport Telematics	X	X	X	X	X	X	X	X
Teleworking	X	X						X
Telecommuting	X	X	X		X	X	X	
Teleconferencing		X	X		X	X		
E-commerce		X	X	X				
Teleshopping				X				
Public tele-Services		X	X			X		X
Distance learning & Education					X		X	X
Entertainment							X	X

Source: Adapted from Lehto, Merci and Himanen (1998) cited in OECD (2002), p. 45.

According to OECD (2002) the relationship between transportation and telecommunication is one involving substitution (trip elimination or replacement), generation (trip stimulation or complementarily) modification or neutrality. Of particular interest is the complementarity relationship which results when the use of one encourages or directly involves the use of the other. Complementary relationship between transport and telecommunication may also result if one increases the efficient use of the other (OECD, 2002).

The overall objective on which this paper is based to explore the relationship between telecommunication and travel demand in the Nigeria case, following the work of Choo and Mokhtarian (2007) that develops a model for considering casual relationship among travel, telecommunication, economic activities among others, using the structural equation model. The details of the synthesized and other hypothesised relationship summary of the model comprising endogenous variable categories and exogenous variable category are contained in their work and summarised in Figure 1.

It is apt to summarise the relationship between and among the various key variables by categories however brief (see Choo and Mokhtarian, 2007, pp 6-10). For instance, the relationship between travel demand and telecommunication demand is hypothesised to be causally bi-directional. The inference of this is that an increase in the demand for telecommunication leads to increase or reduction in travel demand and vice versa. Similarly, the travel (telecommunication) demand and transportation (telecommunications) system infrastructure is equally hypothesised to have a bi-directional causality. The telecommunication network obviously affects the demand for telecommunication, and subsequently may affect the supply of travel.

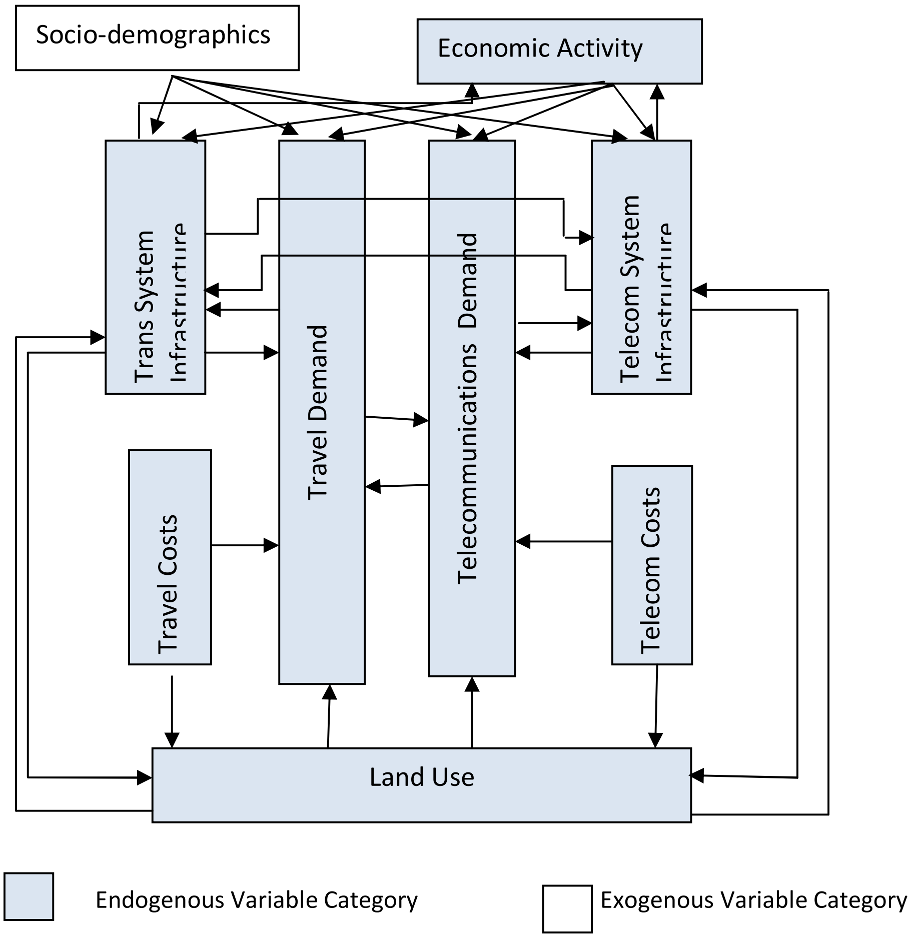

Figure. 1 - Conceptual model of telecommunications and travel relationships
Source: Choo and Mokhtarian (2007), p. 7.

Furthermore, the supposition is that the causality between telecommunications supply and travel supply is bi-directional. This is exemplified by the improved levels of services delivery (e.g. reduced traffic congestion on the highways) provided by transportation system infrastructure as a result of real-time traffic information. Another example is the Intelligent vehicle highway systems (IVHS) programs utilise telecommunications toward increasing the capacity and maximum flow rates on existing roads. The relationship between the cost of and the demand for travel is hypothesised to be bi-directional in that the reduction in prices of telephone calls may lead to increase in the number of telephone calls generated. With reference to the transportation system infrastructure and travel cost relationship, the supposition is that transportation infrastructure negatively affects travel cost. That is increases in transportation supply can reduce travel cost through decrease in travel times.

On the side of demand, supply and land use, the work of Choo and Mokhtarian (2007) also elucidated on the proposition that land use affects travel demands and telecommunication demand. For instance, family members living apart are more likely to call instead of visit each other. Similarly, transport infrastructures have strong influence on land use pattern and housing prices. Therefore, as more people move into the sub-urban areas, telecommunication is needed as well as transport system infrastructure to enhance their accessibilities. Therefore, both infrastructures affect land use and vice versa. Similarly, the relationship between travel cost and land use is hypothesised that travel and telecommunication cost affect land use, especially at the long run.

On demand, supply, economic activity and socio-demographics association, Choo and Mokhtarian (2007) also remarked that "it has long been argued that investment in highway infrastructures (especially, the national highway system) brings economic benefits of national productivity and employment, providing increased mobility of the people and goods ... therefore, telecommunications system infrastructure and economic activity can have bi-directional causality" (p. 9). similarly, economic activities and socio-demographics can affect both travel and telecommunication demand.

3. METHODOLOGY

In the previous section, the conceptual model of telecommunications and travel was discussed, and each causal relationship between variable categories in the model was hypothesized to be either bi-directional or unidirectional.

Structural Equation Modelling (SEM) is a useful tool for analysing the causal relationships among endogenous variables, and between endogenous and exogenous variables. SEM deals with many types of variables including linear, non-linear and latent variables (Choo & Mokhtarian, 2007). The use of SEM is a subset of structural equation modelling under the Roller and Waverman (2001), Belaid (2004), Herrera (2001) and Cadot et al. (2006). Its use is appropriate when a dependent (endogenous) variable in one equation appears as explanatory variable in another equation which leads to a feedback relationship between the variables. Several researches have been conducted on travel demand and travel behaviour using SEM methods (see Golob, 2003 and Choo & Mokhtarian, 2007). In this study, the structural equation modelling method is utilized on time-series data to estimate the causal relationships in the conceptual model. 3SLS by its design incorporates the lag terms of both the dependent and independent variables in the estimation process and therefore takes care of any probable occurrence of non-stationarity and consequential possibility of spurious regressions. There is therefore no need for stationarity tests including the Unit Root Tests involving the use of Augmented Dickey Fuller (ADF) or Phillips-Perron Tests and other similar tests (Greene, 2002). The 3SLS addresses the correction of contemporaneous correlation of error terms which 2SLS is incapable of doing (Zellner & Theil, 1962). The literature is sated with the use of 3SLS for estimation (Roller & Waverman, 2001; Sridhar and Sridhar, 2005; Murty & Soumya, 2005; Parlow, 2011and Tella et al., 2007).

Macroeconometric modelling, in general, pursues two objectives: forecasting and policy analysis. The latter objective is the focus of the analysis of this study. The model reflects the inter-linkages between telecommunications infrastructure and the various sectors of the economy, as well as major variables within the economy. This study adopts the model used by Choo & Mokhtarian (2007) for a similar study in the US with modifications for a developing country like Nigeria. The dataset and proxies used in this study reflect the less than comprehensive data availability prevalent in these climes. All the variables are also time series data at the national level for a period of 30 years (1980 - 2012).

The model which is adapted from Choo and Mokhtarian (2007) consists of 7 behavioural equations is expressed in structural equation form as follows:

$$Dlog(TD_t) = f\,[Dlog\,(TED_{t-k}), Dlog(TS_{t-k}), Dlog(TC_{t-k}), Dlog(LU_{t-k}), Dlog(EC_{t-k}), Dlog(SD_{t-k}), e_{TD,t}] \quad (1)$$

$$Dlog(TED_t) = f\,[Dlog(TD_{t-k}), Dlog(TES_{t-k}), Dlog(TEC_{t-k}), Dlog(LU_{t-k}), Dlog(EC_{t-k}), Dlog(SD_{t-k}), e_{TED,t}] \quad (2)$$

$$Dlog(TES_t) = f\,(Dlog(TED_{t-k}), Dlog(TS_{t-k}), Dlog(LU_{t-k}), Dlog(EC_{t-k}), Dlog(SD_{t-k}), e_{TES,t}] \quad (3)$$

$$Dlog(TC_t) = f\,[Dlog(TS_{t-k}), e_{TC,t}] \quad (4)$$

$$Dlog(TEC_t) = f\,[Dlog(TES_{t-k}), e_{TEC,t}] \quad (5)$$

$$Dlog(LU_t) = f\,[Dlog(TS_{t-k}), Dlog(TC_{t-k}), Dlog(TES_{t-k}), Dlog(TEC_{t-k}), e_{LU,t}] \quad (6)$$

$$Dlog(EC_t) = f\,[Dlog(TS_{t-k}), Dlog\,(TES_{t-k})\, e_{EC,t}] \quad (7)$$

where:

SD = Socio-demographic variables
TD = travel demand variables,
TED = telecommunications demand variables,
TS = transportation system infrastructure variables,
TES = telecommunications system infrastructure variables,
TC = travel cost variables,
TEC = telecommunications cost variables,
LU = land use variables,
EC = economic activity variables
e = error term,
k = Lag (0, 1, 2, . . .) and
Dlog[Xt] = log[Xt] - log[Xt-1].

The definition, nature and sources of key variables are presented Table 2.

The research utilizes the confirmatory research method. Therefore, the set of variables included in a structural equation model strongly depends on the conceptual mode (see Choo & Mokhtarian, 2006). This is contrary to the use of the exploratory research method which yields information to explain problems that are not yet clearly defined or which the real scope is unclear (Osuagwu, 2002).

Table 2 - Key Variable for each variables category

Category	Key Variable	Nature	Source(s)
Travel demand	Petroleum Consumption TD1)	Endogenous	Department of Petroleum Resources, Federal Ministry of Petroleum Resources Central Bank, Statistical Bulletin (Various Edition)
	Yearly Vehicle licensed (TD2)	Exogenous	Federal Road Safety Corp Statistics
Transporta-tion system infrastructure	Length of Roads (TS)	Endogenous	Roads: The Library of Congress Country Studies; CIA World Fact book (2005) http://www.photius.com/ countries/nigeria/economy/nigeria_economy_roads.html 2006 to 2010 extrapolated 4 year average
Travel cost	Real (inflation-adjusted) gasoline price (TC1)	Endogenous	Petroleum Product Price Regulatory Agency (PPPRA)
	Consumer price indices (CPI) (TC2)	Exogenous	National Bureau of Statistics (NBS) Note: Computation of Food and Core CPI started in 1995.
Telecommuni-cation Demand	Telephone lines (per 100 people) Teledensity (TED)	Endogenous	Nigeria Communications Commission (2012). Trends in telecommunications in Nigeria. Retrieved from http// www.ncc.gov.ng/ industry statistics.
Telecommuni-cations system infrastructure	Telephone lines (residential and business lines) (TES1)	Endogenous	Nigeria Communications Commission (2012). Trends in telecommunications in Nigeria. Retrieved from http// www.ncc.gov.ng/ industry statistics.
	Investment in Telecom Infrastructure (TES2)	Exogenous	Central Bank of Nigeria Statistical Bulletin Golden Jubilee Edition December, 2008 Pg. 119 Central Bank of Nigeria Stat, Bulletin December, 2010 http://www.cenbank.org/OUT/2011/ PUBLICATIONS/STATISTICS/2010/PartC/PartC.html
Telecommuni cations costs	Price of Telecom Infrastructure (TEC)	Endogenous	Central Bank of Nigeria Statistical Bulletin Golden Jubilee Edition December, 2008 Pg. 121-124 Central Bank of Nigeria Stat. Bulletin December, 2010 http://www.cenbank.org/OUT/2011/PUBLICATIONS /STATISTICS/2010/Part C/Part C.html
Land Use	Population in urban agglomeration of more than 1m (LU1)	Endogenous	Federal Office of Statistics (FOS) and National Bureau of Statistics (NBS) 2005, 2010). NB: * data obtained from the Statistical Fact Sheet of NBS.
	Ratio of rural to urban (LU2)	Exogenous	Federal Office of Statistics (FOS) and National Bureau of Statistics (NBS) 2005, 2010). NB: * data obtained from the Statistical Fact Sheet of NBS.

Table 2 continued:- Key Variable for each variables category

Category	Key Variable	Nature	Source(s)
Economic Activity	GDP per capital (EC1)	Endogenous	Central Bank of Nigeria Stat. Bulletin Dec., 2007 pg.132-4 Central Bank of Nigeria Stat. Bulletin Golden Jubilee Edition December, 2008 Pg. 118 Central Bank of Nigeria Stat. Bulletin December, 2010 http://www.cenbank.org/OUT/2011/PUBLICATIONS /STATISTICS/2010/PartC/PartC.html
	Disposable personal Income (EC2)	Exogenous	http://www.cenbank.org/OUT/2011/PUBLICATIONS /STATISTICS/2010/PartC/PartC.html
	Unemployment rate (EC3)	Exogenous	Data for 1976 and 1980 were obtained from FOS (1997:99) while the rest were compiled from: CBN-Nigeria: Major Economic, Financial and Banking Indicators, April 1998.
	Interest rate (CBN Discount Rate) (EC4)	Exogenous	Central Bank of Nigeria Statistical Bulletin Golden Jubilee Edition December, 2008 Pg. 43 Central Bank of Nigeria Statistical Bulletin December, 2010 http://www.cenbank.org/OUT/2011/PUBLICATIONS/STATISTICS/2010/PartA/PartA.html Table A.2.4.1
	Labour force, female (EC5)	Exogenous	Federal Office of Statistics (FOS) and National Bureau of Statistics (NBS) 2005, 2010). Household size from 1991 to 2004 based on 2003 Figure; Household size from 1980 to 1989 based on 1990 figure.
Socio-demographic	Population (SD1)	Endogenous	Federal Office of Statistics (FOS) and National Bureau of Statistics (NBS) 2005, 2010). NB:*data obtained from Statistical Fact Sheet of NBS.
	Population growth rate (SD2)	Exogenous	
	Number of households (SD3)	Exogenous	
	Average household size (SD4)	Exogenous	

Source: Authors' compilation (2012).

3.1. Model Estimation

The research developed a model consisting of multivariate simultaneous system of equations that captures the linkage between telecommunications and the demand and supply of travel. The approach is based on the endogeneity of travel (cost and demand), telecommunications (system infrastructure costs, cost and demand), land use and economic activity. The adoption of a system of simultaneous equations approach in preference to the estimation of single equation regression model is predicated on the fact that the former provides more efficient estimates especially where feedback relationship exists amongst the variables (Gujarati, 2003 & Senbil, 2003).

This study employs the three stage least squares (3SLS) to estimate the simultaneous equations because it resolves the possible problem of correlations between equations in addition to addressing the correction of contemporaneous correlation of error terms (Zellner & Theil, 1962). Furthermore, in using the 3SLS, the nature of the data and the established theoretical economic a priori guide the estimation process as well as the discussion of results.

However, the effective use of 3SLS is predicated upon the model satisfying the identification condition (i.e. having unique best estimate). The more exogenous variables there are in a model, the easier it is to achieve identifiability. In the estimated model, all the equations are over-identified. There are 11 exogenous variables (vehicle licensed yearly, consumer price indices (CPI), investment in Telecom Infrastructure, ratio of rural to urban population, disposable personal income, unemployment rate, female labour force, interest rate, population growth rate, number of households and average household size). In addition, there are seven lagged variables. Since the 18 predetermined variables are greater than the summation of the number of endogenous variables in each of the equations, the use of 3SLS is therefore considered appropriate.

The first-order differenced log transformed data which serves as instrumental variables were analysed using E-views@ statistical software after deploying Microsoft Excel@ spreadsheet to prepare the base data. The researchers made use of existing literature to verify the results obtained to come up with preliminary ideas regarding the research problem.

4 RESULTS

The results presented and discussed in the subsequent sections relate only to the models that capture the objectives of the study (Table 3). These results are presented in three parts: (i) determinants of travel demand (ii) determinants of telecommunications demand and supply (iii) direction of the causality between travel demand and the telecommunications (demand and supply). In each of the three sections, specific results in tabular format are also presented and are discussed in turn in the subsequent sections.

4. 1: Determinants of Travel Demand

The estimated results of equation 1 are presented in Table 3. All the explanatory variables: telecommunications demand (teledensity), transport System infrastructure (telephone lines), travel cost (real gasoline price, economic activity (GDP per capita) and social demographics (population) except land use (urban agglomeration of more than 1million), are positively related to the travel demand which is the dependent variable. It is important to note that the 6 variables are all endogenous variables since expectedly, exogenous variables are unexplained by the model. Therefore, in this study, none of the 11 exogenous variables provide explanations for the variation in the travel demand.

The adjusted coefficient of determination ($\overline{R^2}$) which is used to measure the goodness of fit or the explanatory power of a model technically gives the proportion or percentage of the total variation in the dependent variable explained by the regressors. The results show that the six explanatory variables account for 64% ($\overline{R^2}$ = 0.64) variation in travel demand.

The relationship between travel demand and telecommunications demand is statistically significant at 10 percent level with a t-value of (1.334). The telecommunications demand (teledensity) has a coefficient value of 0.09 which means that a percentage increase in the telecommunications demand would result in about 0.1 percent increase in the growth of travel demand.

The GDP per capita which represents economic activity is also statistically significant at 10 percent level both in the current and the immediate prior period. With a coefficient value of (3.1) in the current year, a percentage increase in GDP per capita will result in about 3 percent in the growth of travel demand. An increase of one percent in GDP per capita also results in the rise of travel demand by 2.4 percent in the subsequent year. The transport system is also statistically significant at 10 percent level in explaining variations in travel demand. Indeed, one percent rise causes 2.5 percent increase in the demand for travel. The other regressors (travel cost, population and urban population) are not significant in explaining travel demand.

4.2 Determinants of Demand and Supply of Telecommunications.

4.2.1 Telecommunications Demand

The determinants of the demand for telecommunications demand (teledensity) are demand for travel, telecommunications system infrastructure, cost of telecommunications, urban and total population and the GDP per capita. These variables of interest to this study are responsible for explaining about 46 percent of the variations in its value ($\overline{R^2}$ = 0.46) (see equation 2 in Table 3).

Specifically, the cost of telecommunications (TEC) and the GDP per capita positively and significantly explain the variation in telecommunications demand at 1 percent level. The coefficients of the two explanatory variables are however very small: (0.0009) each. This translates to the fact that one percent increase in each of the cost of telecommunications infrastructure and the GDP per capita will cause little rise in teledensity. This can be ascribed to the fact that for about 75 percent of the study period, the government owned enterprise was solely responsible for the provision of telecommunications infrastructure in a monopolistic arrangement. One of the key variables of interest to this study - demand for travel accounts for variation in the teledensity at 10 per cent significance level although at minimal scale given the coefficient value of (4.75E-05).

Table 3 - System estimation report: Travel demand

		Demand		System infrastructure		Costs		Land Use	Economic Activity	Social Demographic	Eqn
		Travel TD	Telecom TED	Transport TS	Telecom TES	Telecom TEC	Travel TC	LU	EC	SD	
Travel Demand	TD		0.0901 (1. 334) [c]	2.4914 (0.73) [c]			0.1146 (0.9295)	-3.8128 (-0.3018)	3.1201 (1.68585) [c]	0.6869 (0.3018)	1
	TD_{-1}								2.3514 (1.8788) [c-1]		
Telecom demand Teledensity	TED	4.75E-05 (1.9 754)[c]			0.7564 (1.2650) [c]	0.0009 (2.8999)[a]		0.0207 (0.4601) [b]	0.0009 (2.677)[a]	0.7225 (1.707 8) [c]	2
	TED_{-1}		0.3227 (8.1016) [(a-1)]		0.322 (8.142 8) [(a-1)]			0.0661 (1.7863) [(c-1)]	0.007 (1.9892) [(b-1)]		
Telecom System Infrastructure	TES		1.000174 (1207) [a]	0.0013 (0.5976)				0.0269 (0.5362)	0.0103 (3.0967) [a]	0.8913 (1.8633) [c]	3
	TES_{-1}		0.3328 (8.171) [(a-1)]					-0.0717 (-1.8617) [(c-1)]			

R-squared	Adjusted R-squared $\overline{R^2}$	Durbin-Watson	Eqn
0.6883	0.6454	0.331694	1
0.46127	0.459790	2.028267	2
0.999971	0.999955	3.017140	3

Source: E- Views[TM] (version 6.1) and Author's computations

Note: a, b, c, imply 1, 5 and 10 percent significance level respectively. t-statistic in parenthesis . (-1) lagged by1 year

The urban population in the current period is statistically significant at 5 per cent level. The following variables in the immediate prior year's (teledensity, telecommunications systems infrastructure GDP per capita and land use) also significantly influence telecommunications demand. The telecommunications system infrastructure and the total populations are considered significant at 10 percent. The demand for telecommunications in the immediate past year also drives the demand of the current year. This is made manifest by the 1 percent level statistical significance of the prior year's demand with a coefficient of 0.32. This implies that one per cent increase on prior year's demand will spur current year's teledensity by 0.32 percent.

4.2.2 Telecommunications Supply

The estimated results of equation 3 in Table 2 show that the five regressor- variables account for 99.9% variation in travel demand. The adjusted coefficient of determination ($\overline{R^2}$ = 0.999). The high values of adjusted coefficient of determination ($\overline{R^2}$) although indicative of a specious result, can be considered valid in view of the fact that the Durbin-Watson Statistics (3.01) is higher than the $\overline{R^2}$ (Greene, 2002).

The relationship between telecommunications infrastructure (supply) and telecommunications demand is statistically significant with a t-value of (1.0002) at 1 percent level. Its one year lagged value is also significant at 1 percent with coefficient value of (0.3329). The import of this is that a percentage increase in the telecommunications demand in the current and immediate past year would result in about 1 percent and 0.33 percent increase in the supply of telecommunications infrastructure. The GDP per capita and urban population of the immediate past year are also significant at 1 per cent and 10 percent level respectively. One percent rise in the prior year population and the current year urban population will cause a boost of the supply of telecommunications system infrastructure by 0.07 percent and 0.09 percent respectively. The GDP per capita representing the economic activity is also statistically significant at 1 percent level in the current year. With a coefficient value of (0.01), a percentage increase in the GDP per capita would result in about 0.1 percent rise in the supply of telecommunications infrastructure.

4. 3 Direction of the Causality between Telecommunications and Travel demand.

This section examines the causal relationship between travel demand and telecommunications. From the presentation in the preceding sections, the relationship between travel demand and telecommunications demand from the estimated equation 1, is statistically significant at 10 percent level with a coefficient value of 0.9 and t-value of (1.334). From Table 4, it is manifest that travel demand serving as the dependent variable is partially explained by the demand for telecommunications at 10 percent level (see Eqn. 4)

On the other hand, there is a reversed causal relationship in the direction of telecommunications demand (equation 5). Travel demand is positively and significantly related to telecommunications demand at 10 percent level. The coefficient of the dependent variables is however very small: (4.75E-05). It is essential to reiterate the import of equation 3 which as earlier discussed in section 4.2.2 above is that the supply of telecommunications (proxied by the telecommunications system infrastructure) is also determined by travel demand at 1 percent level.

Table 4- System estimation report: Causal relationship between the travel demand, and telecommunications demand

	Travel Demand (TD)	Telecom Demand (TED)	Equation
Travel Demand (TD)		0.0901 (1.334)[c]	(4)
Telecom Demand (TED)	4.75E-05 (1.9754)[c]		(5)

Source: E- Views™ (version 6.1) and Author's computation.
Note: a, b, c imply 1, 5 and 10 percent significance level respectively. t-statistic in parenthesis . (-1) lagged by1 year

The consequential effect of the evaluation of the equations 3, 4 and 5 is the existence of reverse causality between the demand and supply of telecommunications on one hand and the travel demand on the other. In effect, the increase in travel demand will cause a rise (no matter how little) in the telecommunication demand. This is in line with the complementarily theory.

4. 4: Post Estimation Tests

The results of the post-estimation tests conducted to ascertain the reliability of the estimates show that the disturbances are normally distributed. Jarque-Bera test obtained shows that the Null hypothesis cannot be rejected in view of the probability value of the Skewness (0.91) Kurtosis (0.26) and of the joint estimation of (0.64) which are greater than the traditional value of (0.10).

In addition, the serial correlation tests show that the present value of the residuals does not depend on their past values. For the estimated result of the test, the research found that there is no serial correlation problem up to lag 12 for the system variable models. Specifically, the probability values for lag 1 through 4 in Table 5 are far greater than the conventional level of significance of 5 percent (0.05) implying that there is no serial correlation.

Table 5 - System Portmanteau tests for autocorrelations

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	55.94	0.23	57.93	0.18	49
2	105.61	0.28	111.29	0.17	98
3	148.38	0.45	158.99	0.24	147
4	181.30	0.77	197.18	0.46	196

Source: E- Views^{TM} (version 6.1) and Author's computation.
Note: *df* is degrees of freedom for (approximate) chi-square distribution.
Null Hypothesis: No residual autocorrelations up to lag *h*.

5 CONCLUSIONS

This study presents a mass of literature position that there is a direct positive impact of various types of infrastructural services on development indicators and that a better transportation system and a safer road network help to raise standard of living. Telecommunications development shows a clear positive relationship with demand for travel with consequential impact on economic growth. One significant effect of economic growth and development is increasing travel demand with its attendant transport externalities including increasing rate of accidents, pollution, congestion, and urban sprawl. The striking relationship between telecommunication demand and economic growth therefore is worth exploring with a view to determining their causality and the extent to which one can support the other towards overall national development.

This paper adopted the conceptual model of telecommunications and travel demand and each causal relationship between variable categories in the model hypothesized to be either bi-directional or unidirectional as discussed based on the work of Choo and Mokhtarian, (2007). It used the structural equation modelling (SEM) which is a useful tool for analyzing the causal relationships among endogenous variables, and between endogenous and exogenous variables. All the explanatory variables categories: telecommunications demand, transport System infrastructure, travel cost, land use, economic activity and social demographics are positively related to the travel demand, with the results showing that the six explanatory variables account for 64% variations in travel demand.

The relationship between travel demand and telecommunications demand is also found to be statistically significant with a percentage increase in the telecommunications demand potentially resulting in about 0.1 percent increase in the growth of travel demand. The import of this is that the rise in teledensity in the current increases the need for travelling in line with the complementarity theory of travel demand and telecommunications relationship.

The relationship between telecommunications infrastructure (supply) and travel demand is also found to be statistically significant to the extent that increase in the telecommunications demand would result in about similar percent increase in the telecommunications system infrastructure. The same trend is similar to population and the urban population and the supply of telecommunications system infrastructure.

In terms of the direction of the causality between travel demand and telecommunication demand, the relationship is bi-causal but the degree of impact is different, more towards the direction of telecommunications demand. In effect, the increase in travel demand will cause less rise in the telecommunication demand than otherwise.

On the side of telecommunications demand, it is imperative that sustainable government support to the private sector investment and funding of the infrastructural investment are required to provide the population with adequate telephone communications. The funding of specialized industries has been adopted as strategy for growth by some emerging economies.

One of the findings of this study is the positive but insignificant impact of the output of telecommunications infrastructure on travel demand. In order to encourage mobility across the country, particularly in the rural areas, the Nigerian government should consider providing further concessionary fiscal incentives to investors who are willing to commit resources to these marginally profitable areas of telecommunications. Some incentives ought to be provided to such telecommunications operators in order to help the liquidity and net worth position of these investor-companies. This will be invaluable, especially as telecommunications infrastructure investment is concomitant to economic growth and travel demand.

An important methodological limitation of this study is that ordinarily, a structural break analysis would have been desirable to provide opportunity of comparing the impact before and after the deregulation of the industry. However, the study did not conduct structural break analysis because the post-deregulation period remains too short for any meaningful explanation especially in the absence of some quarterly data. Also, the use of some proxies and the need for some data transformation may have affected the integrity of the data. The monetary sector has not been included in the model because for the greater part of the study period, government alone was responsible for financing infrastructure in the telecommunications sector. Government spending is through appropriation and therefore not affected by market forces.

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