Analysis of Accessibility Impact On Commercial Property Values In Ikeja, Nigeria

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Abstract

A number of factors determine commercial property values with road network being one of them. This study was carried out to determine the contributions of arterial road network to variability in commercial property values in Ikeja, Nigeria, in the presence or absence of other value determinants. In attaining the aim, road network was decomposed into its explanatory variables and regression models set at 0.05 alpha level used to determine their individual and joint impacts with other factors on commercial property values. It was found that accessibility has a P-value of 0.0024; demand, P-value = 0.0011; and supply returned P-value of 0.0059; all have significant impact on commercial property values. Also, the Analysis of Variance indicates that F-ratio = 3.88, P-value = 0.0193, with R^2 of 69.37% explaining 69% variability in commercial property value. However, further analysis using Backward Selection Method of Stepwise Regression Model indicated that location in addition to demand, supply, and accessibility have significant impacts on commercial property values in the study area. It recommended that road network be improved to enhance values of commercial properties in the study area to the benefit of Government through enhanced property tax; to property owners through improved rental values; and occupiers of commercial properties through better neighbourhood quality.

Key Words: *accessibility, road network, commercial property, property value, road network, valuation*

1.0 Introduction

Roads may be classified as international, inter-city or intra-city; international and inter-city roads are usually major or arterial roads while intra-city roads are routes within a city and may be minor or major (arterial). The pattern of road network somewhat influences ease of movements and provides accessibility to various land uses which compete for available spaces along the arterial roads. Commercial properties cluster along such roads to benefit from the advantages of agglomeration. Also, competition makes locations along the arterial roads to be at their highest and best uses, which translate into high rental values compared to other locations that lack such competition.

As result of the advantages, developers, financiers and investors in commercial properties require data on the level of rental income that a development project could reasonably be expected to realize in a transaction involving willing and able parties to such project. In addition, the overall impact of risks and uncertainty in the property market calls for tool to aid in predicting the future trend in commercial property market with some measure of accuracy. This is to ensure that income that a given commercial property generates in the nearest future will continue to recoup the capital outlay and be sustained subsequently.

In the choice of site for real estate development, the investors usually desire the location with potentials for high positive net return. In many cases, decisions on site selection are based on intuition or mere subjective assumptions, especially in developing economies; this often leads to defective and abandoned projects. For viable project development projects, proper site selection is largely related to accessibility with the innate assumption that must be based on scientific techniques.

A number of approaches have been adopted in determining the most accessible site and that is most likely to be viable in terms of demand for a proposed development project upon its completion. In other words, the techniques assist in explaining the effects of accessibility on property values. The modern techniques include cummulative-opportunity type measure, gravity-based measure, weighted-average distance, utility-based measure, space syntax, route structure analysis, multiple regression model, hedonic model, expert system heuristics, and graph theory (see Cole and King, 1968; Hay, 1973; Ogunsanya, 1986; Rallis, 1988; Geertman and Ritsema, 1995; Kwan, 1998; Wyatt, 1999; Aderamo, 2003; Marshall, 2005; Oni, 2009).

It is pertinent to state that decision on site selection and accessbility in developing economies is often based on intuition and mere physical observation of the neighbourhood in which a proposed development project is to be located. Many of the real estate investments have become stalled, abandoned, or non-viable upon completion due to faulty decision on site selection. The aim of this study is therefore to determine the impact of the explanatory variables of road network (road density, length of road, accessibility), demand, supply, and location on commercial property values using Ikeja, the capital of Lagos State, Nigeria for the study.

2.0 Literature Review

In explaining the pattern of property values in relation to transportation, Lean and Goodall (1977) opined that the centre of an urban area is the position of greatest accessibility where transport routes and systems converge. Competition between firms whose revenue is high when in such a position will force up rents and land values above those in the remainder of the urban area. Firms will compete to locate in the centre to take advantage of complementarity, which to a large extent, is a function of accessibility. The larger the urban areas the more distinct will the clusters of complementary uses become. Similarly, the higher the degree of accessibility and complementarity the higher the land values in the centre are likely to be. As accessibility decreases from the centre, it is expected that commercial property values will decrease.

According to Aderamo (2003), road network constitutes important element in urban development as roads provide accessibility required by different land uses in the urban areas; and proper functioning of such urban areas depends on efficient transport network, which is backbone to their very existence. The analysis of the road network involves recognition of the patterns and qualities of the roads, which can be emphasized through process of abstraction and symbolization. Road network pattern is an arrangement and connectivity of nodes and links measuring the spatial structure of road networks, which are large amount of inter-woven roads that exhibit star-like, grid-like and irregular shapes (Xie and Levinson, 2006; Zang and Lund University, 2004; Mackaness and Edwards, 2002; Moilanen and Nieminen, 2002; Doak et al, 1992; Taylor, 2000; Lindenmayer and Possingham, 1996; Schumaker, 1996; With et al., 1999; and Tischendorf and Fahrig, 2000).

Two types of analysis are based on graph theory; these are conventional transport network analysis and syntax, a method of analyzing urban spatial structure (Thompson, 1948; Berge, 1958; Hagget and Chorley, 1969; March and Steadman, 1971; Kruger, 1979; Hillier and Hanson, 1984; and Broadbent, 1988). A number of techniques have been used which include urban morphology (Conzen, 1969; Whitehand, 1981; Moudon, 1997), fractal analysis (Batty and Longley, 1994), cellular automata (Batty, 1997), traffic pattern analyses (Vaughan, 1987; Taylor, 2000), and graph theoretic approach (Muraco, 1972). Other techniques are connectivity, shortest path spanning tree, and minimum cost spanning tree to facilitate structural analysis and road selection in road networks have equally been used by Mackaness and Edwards (2002), Jiang and Claramunt (2004), and, Jiang and Harrie (2004). Thomson and Richardson (1999) used perceptual grouping of roads into segments according to continuation principle by ordering and selecting strokes into which the roads are segmented, while agent-simulation approach consisting of algorithm base for road generalization was adopted to create version of network of roads that exhibits certain properties which includes connectivity, length of roads, degree of continuation, and degree and frequency of usage (Morisset and Ruas, 1997).

Network analysis reduces complex transportation network to elements of nodes making evaluation of alternative structures possible through use of elementary mathematics from graph theory (Hodder and Lee, 1982). Various studies have adopted the theory amongst which are Garrison and Marble (1960), and Nystuen and Dacey (1961). The former applied graph theory in measuring regional highways in the United States of America, while the latter analyzed functional connection between central places in Washington using communication flows in a network. In addition, Muraco (1972) used the concept in studying intra-urban accessibility in Columbus and Indianapolis, USA, and in estimating traffic flow in Barnsley, U.K. (Ogunsanya, 1986).

Aderamo (2003) applied the graph theoretic techniques in studying the growth of intra-urban network in Ilorin, Nigeria; Oni (2007a) adopted the technique to analyze accessibility and connectivity in the road network of a metropolitan area; while Oni (2007b, 2008) similarly adopted the technique to determine the degree of accessibility and connectivity of nodal points within a university community in Nigeria. The works succeeded in determining the degree of accessibility and connectivity of nodal points in the road network of the study areas but did not relate the degree and levels of such accessibility and connectivity to commercial property values, which the present study intends to achieve.

A number of factors affect commercial property values in Nigeria. These include institutional and economic factors, location, complementary uses, competition amongst and between uses, design, degree of obsolescence, accessibility, road network, relationship between landlord and tenant, and negative externalities (McCluskey et al, 2000; Kauko, 2003; Kuye, 2003; Oyebanji, 2003; Omoogun, 2006). These studies have focused on the factors in relation to commercial property values with less emphasis on road network that drives many of them.

The aim of this study is therefore to determine the impact of the explanatory variables of arterial road network in the presence or absence of other commercial property value determinants. In doing so, one hypothesis was set and stated as follows: "there is no statistically significant impact of the explanatory variables of arterial road network on commercial property values in the study area in the presence or absence of other commercial property value determinants".

The study area, Ikeja, is the capital of Lagos State and a large component of the Lagos metropolis. Lagos State is one of the thirty-six states in the Federal Republic of Nigeria. It is located on 6°34'60"N, 3°19'59"E along the West African coast. There are ninety (90) major roads in the study area out of which thirty-seven (41.1%) are arterial. From the thirty-seven arterial roads, twenty actually traverse the commercial axes while seven serve the institutional, industrial, and residential neighbourhoods. This study covers only the major roads within the commercial axis and inner areas to the excluding of the inter-city roads that form rings around the study area.

3.0 Material and Method

Using the graph-theoretic technique, the road map of the study area showing major transport routes was converted to linear graph regardless of the width, quality, and standard of the roads. The points at which two or more roads connect are numbered serially from 1 until the entire nodal points in the network have been completely numbered. From this, accessibility matrix was prepared to determine the degree of accessibility of each node within the road network, and each node was rated according to the level of accessibility using the Shimbel index. The Shimbel index matrix summarizes the number of edges required to connect every node or vertex with the others in the network and through the shortest path. The nodal points with the lowest index thus revealed the most accessible location in the study area.

In this case, Fig. 1 shows the satellite map of the study area with the total number of arterial roads traversing the neighbourhoods. The satellite map was coverted to graph of the network by connecting the nodal points through the straight and shortest path possible. This was accomplished by placing transparent sheet on the satellite map and drawing straight lines to connect the nodal points to form the edges.

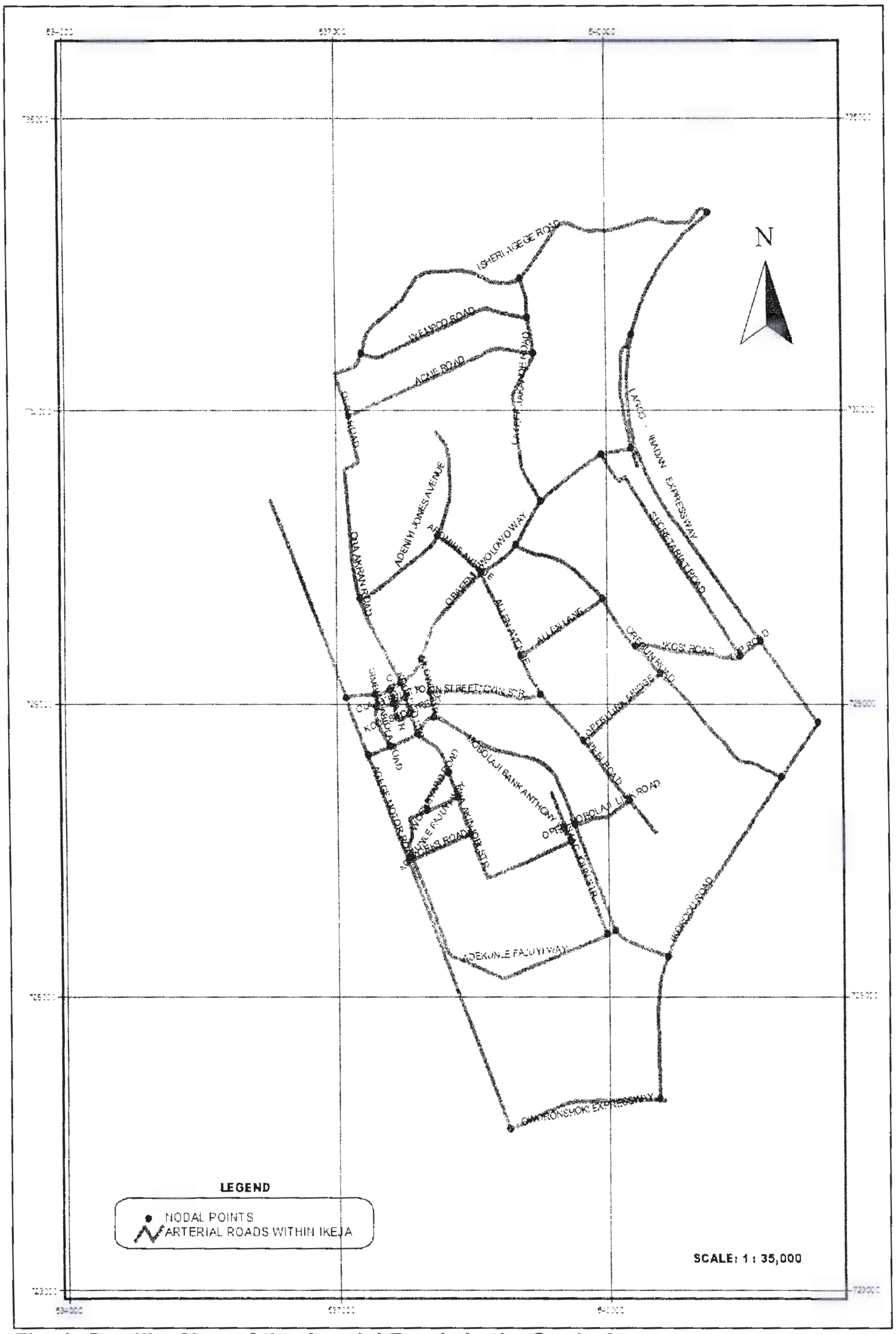

Fig. 1: Satellite Map of the Arterial Roads in the Study Area
Source: Lagos State Planning Information Centre, Ikeja

Furthermore, the relative accessibility indices of the roads were determined. In this case, Fig. 1 was converted to linear graph regardless of the width, quality, and standard of the roads and the nodal points were numbered from 1 to 35 as shown in Fig 2.

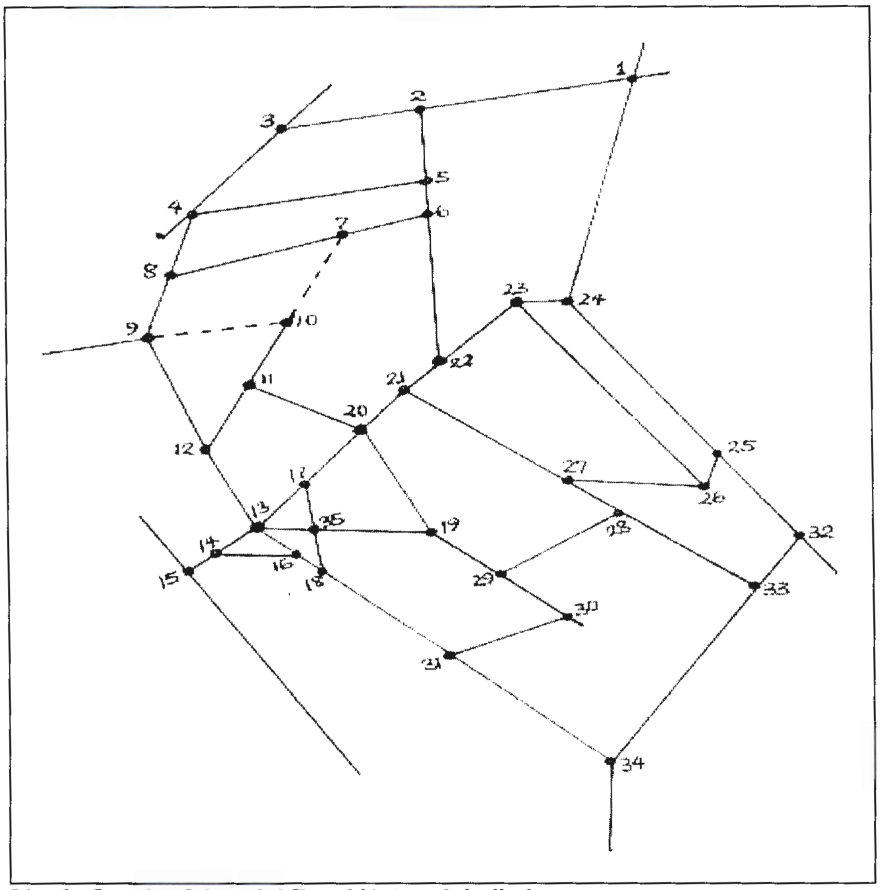

Fig. 2: Graph of Arterial Road Network in Ikeja
Source: Oni (2009)

As shown in Fig. 2, thirty-five (35) nodal points were revealed within the study area, and a 35-by-35 column matrix corresponding to the number of nodal points to form the links. The number of links between a nodal point and every other with which it has direct link was indicated in each box to obtain the accessibility index, which is the total for each point; this represents the level of accessibility of each road axis. The process was repeated for every other road until the entire networks was covered. The totals indicated in the accessibility index column thus represent the ranks to determine the relative accessibility as shown in Tables 1 and 2 (See Appendix). However, in operationalizing the accessibility indices for thirty-five nodal points and weighted over the twenty arterial roads encompassed within the road network to obtain the levels of accessibility in the network using Eqn. 1 formulated by Oni (2009).

$$a,(c)_i = \frac{np_{1i} + np_{2i}}{\sum(rnp_1 + rnp_2)} \times \frac{rnp_1}{rnp_2} \qquad \textbf{...Eqn. 1}$$

where,
$a(c)_i$ = accessibility (or connectivity) index;
np_{1i} = accessibility (or connectivity) index of lower nodal point;
np_{2i} = accessibility (or connectivity) index of higher nodal point;
rnp_1= rank for lower nodal point;
rnp_2= rank for higher nodal point;

Traffic density was measured in terms of volume of vehicles over the entire land area. This determines the number of vehicles per square metre of land area and it is an indication of level of congestion in the study area. Data on traffic volume obtained from the Lagos State Traffic Management Authority (LASTMA) was determined by direct traffic counts along each of the arterial roads at specific hours over a six-month study period. The number of vehicles was subsequently related to the entire size of the study area. Length density expresses the relationship between individual length of arterial roads and total length of all arterial roads in the study area. The length of each road was determined and expressed in relation to total of lengths of all roads in the study area.

Quality of road was measured by direct observation of each arterial road in terms of width (whether dual carriage), lack of potholes, and motor-ability. A figure ranging between 1 and 5 was assigned to each arterial road depending on category of its quality, 5 represented the best quality and 1 the least. Arterial road that was tarred, motorable, with dual carriage and without potholes that could hinder vehicular movements was assigned 5; 4 for those that are tarred, motorable, having dual carriage but with potholes; 3 to road that was tarred, single carriage, with potholes but motorable. The road was tarred, with single carriage way, motorable and having potholes was assigned 2; while the road that was tarred, single carriage, having potholes and are un-motor able is assigned 1. The width of road was measured by direct observation and physical measurement. Points were allocated based on whether the road is single- or dual- carriageway, dual carriage is assigned 2 while single carriage way is assigned 1 in the analysis.

Density of each road was measured by calculating the unit length of road in the network over total land area in the study area, and expressed as length per square metre. Eqn. 2 as formulated by Oni (2009) represents measure of density for each road in the network.

$$r_d = \frac{\sum_{i=1}^{n} lr_i}{A} \qquad \text{...Eqn. 2}$$

where,

r_d = road density; $lr_{i...n}$ = length of individual road; A = entire land area covered by the study area.

Demand for commercial properties was determined by analyzing the aggregate demand for income properties and it is the sum of all the quantities requested for by willing and able prospective tenants as available in the records of each firm of Estate Surveyors and Valuers in the study area. Aggregate demand was obtained by combining all demand schedules by individual firms in the property market. The aggregate transaction-based requests for commercial properties on yearly basis obtained from the Estate Surveyors and Valuers over a five-year period was determined; average of effective requests over the period indicated for each arterial road was derived. Similarly, the supply of commercial properties was derived from sum of all the number of commercial properties fully let in transactions involving willing and able tenants and owners acting through the firms of Estate Surveyors and Valuers. This represents the number of letting transactions effectively completed by firms within the five-year study period to arrive at average number of the transactions.

In measuring the location attribute indices, the most accessible nodal point in the network of arterial roads was used as central point to which other locations were related. In doing so, the number of links from the farthest point on each road in the network was counted to the most accessible location in the network, taking the shortest routes possible. This resulted in location indices shown in Table 3.

Table 3: Location indices of Arterial Roads in Ikeja

S/N	Road	Location index
1	Oba Akran Avenue	4
2	Kodesho Street	6
3	Obafemi Awolowo Way	5
4	Adeniyi Jones Avenue	3
5	Aromire Avenue	2
6	Allen Avenue	2
7	Opebi Road	4
8	Opebi Rd/Bank-Anthony Way	5
9	Bank-Anthony Way	6
10	Lateef Jakande Road	4
11	ACME Road	4
12	WEMPCO Road	4
13	Ogba Road	6
14	Isheri-Agege Road	5
15	Oregun Road	3
16	Ikosi Road	3
17	Olowu Street	3
18	Simbiat Abiola Way	4
19	Toyin Street	3
20	Opebi Link Road	2

Also, the average rental values of commercial properties along each arterial road were obtained by summing up the open market rents that prevailed for a period of five-years and expressed in Naira per square metre per annum as shown in Table 4.

Table 4: Average Rental Values of Commercial Properties along the Arterial Roads in Ikeja (2009 – 2013)

S/N	Road	2009	2010	2011	2012	2013
1	Allen Avenue	6,000	6,500	8,500	10,000	15,000
2	Adeniyi Jones Avenue	6,000	6,500	8,500	8,500	15,000
3	Opebi Road	6,000	6,500	9,000	8,000	15,000
4	Bank-Anthony Way	7,000	7,500	8,000	7,800	18,500
5	Oba Akran Avenue	7,200	7,500	8,500	8,000	16,500
6	Bank-Anthony/Opebi Way	6,000	6,500	8,000	8,000	15,000
7	Toyin Street	6,600	6,600	8,500	10,000	12,000
8	Aromire Avenue	6,000	6,500	8,500	10,500	15,000
9	Kodesho Street	5,500	6,200	8,500	8,500	15,000
10	Ogba Road	4,600	6,500	8,000	8,000	12,000
11	Awolowo Way	6,500	6,500	8,000	10,000	15,000
12	Simbiat Abiola Road	6,000	6,500	8,500	15,000	15,000
13	ACME Road	4,500	4,500	8,000	8,000	16,500
14	Lateef Jakande Road	4,000	7,000	7,500	9,500	12,000
15	Olowu Street	4,500	5,500	6,500	8,500	10,500
16	Opebi Link-Road	4,500	6,600	7,500	8,000	10,000
17	Oregun Road	4,000	7,500	7,500	9,000	12,500
18	WEMPCO Road	4,000	7,500	8,000	12,000	16,500
19	Ikosi Road	3,500	7,000	7,000	8,000	10,000
20	Isheri/Agege Road	3,000	6,000	7,500	7,500	10,000

4.0

Analysis and Discussion

In testing the hypothesis that "there is no statistically significant impact of the explanatory variables of arterial road network on commercial property values in the study area in the presence or absence of other commercial property value determinants", the road network was decomposed into its explanatory variables of traffic density, road density, length density, accessibility, and road quality. This was in addition to other factors like demand, supply, and location indices of each road in the network. The average rental values of commercial properties as at 2013 expressed in Naira per square metre per annum as shown in Table 4 above were adopted as the dependent variable.

Furthermore, the accessibility indices were derived using graph theoretic analysis of the arterial roads by tracing out the arterial routes (in Fig. 1) using transparent paper to derive graph of the roads shown in Fig. 2 The resulting graph in Fig. 2 above though qualitative in nature was transformed into quantitative data by converting the road network into linear graph, each route represented by single line regardless of width, quality and standard analyzed to obtain required quantitative data. The connectivity and accessibility matrixes were derived from Fig. 2. This involved numbering of nodal points in the graph serially. Indexes for accessibility and connectivity were thereafter determined and indicated in the Shimbel matrixes (Appendices 1 and 2).

The matrixes summarize the number of edges required to connect each node or vertex with every other nodes in the network through the shortest path, while the connectivity matrix indicates nodes with the highest total number of connections or linkages to every other node in the network. In the connectivity matrix, a score of 0 or

1 was given to each node, that is, where two nodes are directly linked; a value of 1 point was given. Where two nodes have no direct link, a score of 0 point is assigned. The connectivity matrix therefore shows the number of other nodes that a particular node is directly linked with and the node with the highest total number of points is considered as most connected. Similarly, the node with the least Shimbel index is regarded as the most accessible.

As shown in Fig. 2, twenty arterial roads in the network encompassed thirty-five nodal points. In measuring the accessibility and connectivity indices for thirty-five nodal points in the road network, each point was weighted in relation to the arterial roads to obtain accessibility and connectivity indices in the network using Eqn. 1 formulated by Oni (2009).

$$\beta\ a,(c)_i = \frac{\delta p_{1i} + \delta p_{2i}}{\Sigma\,(r\delta_1 + r\delta_2)} \times \frac{r\delta_1}{r\delta_2} \qquad \text{...Eqn. 1}$$

where,

$\beta\ a(c)_d$ = weighted accessibility or connectivity index;

δp_{1i} = accessibility or connectivity index of lower nodal point;

δp_{2i} = accessibility or connectivity index of higher nodal point;

$r\delta_1$= rank for lower nodal point; and

$r\delta_2$= rank for higher nodal point.

The application of Eqn. 1 resulted in weighted accessibility and connectivity indices shown in Table 5.

Table 5: Weighted Accessibility and Connectivity Indices

S/N	Arterial Road	Weighted Connectivity Index	Weighted Accessibility Index
1	Opebi Link-road	0.02	0.10
2	Kodesho Street	0.08	0.55
3	Simbiat Abiola Way	0.10	0.57
4	Oregun Road	0.14	0.58
5	Toyin Street	0.15	0.64
6	Oba Akran Avenue	0.18	0.64
7	Bank Anthony Way	0.18	0.65
8	Awolowo Way	0.23	0.69
9	Aromire Avenue	0.23	0.72
10	Allen Avenue	0.23	0.73
11	Opebi Road	0.24	0.73
12	Lateef Jakande Road	0.25	0.73
13	Opebi/Bank-Anthony Way	0.26	0.73
14	Adeniyi Jones Avenue	0.27	0.74
15	WEMPCO Road	0.27	0.74
16	Ikosi Road	0.29	0.74
17	ACME Road	0.33	0.74
18	Isheri-Agege Road	0.33	0.74
19	Olowu Street	0.34	0.74
20	Ogba Road	0.35	0.75

The summary results of the analysis of the various explanatory variables discussed in this sub-section is given in Table 6.

Table 6: Summary of Explanatory Variables Affecting Commercial Property Value in Ikeja

S/N	Road	Traffic volume	Road Length (in metres)	Traffic Density	Road Density	Connectivity	Road Quality	Accessibility	Supply	Demand	Location
1	Oba Akran Avenue	16,651	2,307.18	7.22	0.06	0.18	4	0.74	14	18	4
2	Kodesho Street	16,240	559.465	29.03	0.01	0.08	4	0.74	6	9	6
3	Obafemi Awolowo Way	19,042	4,292.12	4.44	0.11	0.23	5	0.10	15	35	5
4	Adeniyi Jones Avenue	12,211	2,233.46	5.47	0.06	0.27	4	0.74	15	21	3
5	Aromire Avenue	17,414	616.81	28.23	0.02	0.23	4	0.73	7	9	2
6	Allen Avenue	18,038	1,411.30	12.78	0.04	0.23	5	0.74	22	29	2
7	Opebi Road	16,510	1,886.00	8.75	0.05	0.24	4	0.74	16	21	4
8	OpebiRd/Bank-Anthony Way	18,392	674.13	27.28	0.02	0.26	5	0.74	4	7	5
9	Bank-Anthony Way	17,186	4,718.66	3.64	0.12	0.18	5	0.57	13	17	6
10	Lateef Jakande Road	17,173	2,443.60	7.03	0.06	0.25	4	0.58	8	11	4
11	ACME Road	18,433	2,200.49	8.38	0.06	0.33	4	0.75	6	6	4
12	WEMPCO Road	14,898	1,963.85	7.59	0.05	0.27	4	0.73	5	5	4
13	Ogba Road	15,539	1,121.50	13.86	0.03	0.35	4	0.64	4	5	6
14	Isheri-Agege Road	12,816	5,080.41	2.52	0.13	0.33	5	0.64	5	5	5
15	Oregun Road	18,276	3,888.18	4.70	0.10	0.14	5	0.65	9	10	3
16	Ikosi Road	14,900	1,207.08	12.34	0.03	0.27	3	0.73	2	3	3
17	Olowu Street	14,626	623.96	23.44	0.02	0.34	3	0.73	7	9	3
18	Simbiat Abiola Way	17,517	571.44	30.65	0.02	0.10	4	0.72	6	8	4
19	Toyin Street	13,608	875.48	15.54	0.02	0.15	5	0.55	23	27	3
20	Opebi Link Road	18,796	1,106.57	16.99	0.02	0.02	5	0.69	4	5	2
	Total	**328,266**	**39,781.68**								

In testing the stated hypothesis, multiple linear regression models were used for analysis to determine the relationship between the dependent and independent variables, which are commercial property values and the explanatory variables respectively. The application of Statgraphic statistical software package for the regression analysis resulted in details shown in Tables 7 and 8.

Table 7: Summary Statistics of the Regresses Explanatory Variables

Parameter	*Estimate*	*Standard Error*	*T-Statistic*	*P-Value*
CONSTANT	-2037.64	1815.84	-1.12214	0.2838
traffic density	8.52076	30.3877	0.280402	0.7839
connectivity	629.94	1815.69	0.346943	0.7346
accessibility	7700.16	2007.38	3.83592	0.0024
supply	-315.664	94.65	-3.33506	0.0059
demand	300.404	70.3627	4.26937	0.0011
location	217.528	133.096	1.63437	0.1281
road density	7322.52	7890.2	0.928053	0.3717

Table 8: Analysis of Variance

Source	*Sum of Squares*	*Degree of freedom*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1.12374E7	7	1.60534E6	3.88	0.0193
Residual	4.96172E6	12	413476.		
Total (Corr.)	1.61991E7	19			

R-squared = 69.3704 percent; R-squared (adjusted for d.f.) = 51.5032 percent; Standard Error of Est. = 643.021; Mean absolute error = 353.955; Durbin-Watson statistic = 1.59831 (P=0.0996); Lag 1 residual autocorrelation = 0.127342

The output shows the results of fitting a multiple linear regression model to describe the relationship between Commercial Property Value and 7 independent variables. The equation of the fitted model is

*Commercial Property Value = -2037.64 + 8.52076*traffic density + 629.94*connectivity + 7700.16*accessibility - 315.664*supply + 300.404*demand + 217.528*location + 7322.52*road density* **...Eqn. 2**

Since the P-value in Table 8 is less than 0.05, there is a statistically significant impact of the explanatory variables on commercial property values in the study area at the 95.0% confidence level.

The R-Squared statistic indicates that the model as fitted explains 69.3704% of the variability in Commercial Property Value. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 51.5032%. The standard error of the estimate shows the standard deviation of the residuals to be 643.021; and the mean absolute error (MAE) of 353.955 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file and since the P-value (P=0.0996) is greater than 0.05, there is no indication of serial autocorrelation in the residuals at the 95.0% confidence level.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0.7839, belonging to traffic density; since the P-value is greater or equal to 0.05, traffic density is not statistically significant at the 95.0% or higher confidence level and consequently could be removed from the model.

Since the P-value in ANOVA Table (Table 8) of 0.0193 is less than 0.05, it confirms that there is statistically significant impact of the explanatory variables on commercial property value at 95.0% or higher confidence level. Therefore, the null hypothesis is rejected. In addition, R^2 of 69.37 in the output indicates that the model as fitted explains approximately 69% variability in commercial property values in the study area.

Specifically, the analysis shows that the explanatory variables of road network, in the presence of accessibility, supply and demand, jointly have statistically significant impact on commercial property values in the study area. By implication, other determinants of commercial property values not considered most likely account for the remaining 30.63%. The other factors probably include serenity of neighbourhoods within which it is located, effect of adjoining properties, facilities available in the property, security of life and property in the neighbourhood, national and global economy, political situation, facilities available in a particular commercial property and others.

Furthermore, traffic density, road connectivity, location, and road density have no significant impact on commercial property values in the study area. However, it may be misleading to conclude that these variables should be ignored since removal or addition of one or more of the variables may have significant effects on the model. It is therefore important to extend the analysis by using a Stepwise regression analysis to find the best model that contains only statistically significant variables as follows:

Stepwise regression
Method: backward selection
F-to-enter: 4.0
F-to-remove: 4.0

Step 0:
8 variables in the model. 11 d.f. for error.
R-squared = 69.37% Adjusted R-squared = 47.09% MSE = 451064.

Step 1:
Removing variable road quality with F-to-remove =0.0000206455
7 variables in the model. 12 d.f. for error.
R-squared = 69.37% Adjusted R-squared = 51.50% MSE = 413476.

Step 2:
Removing variable traffic density with F-to-remove =0.0786251
6 variables in the model. 13 d.f. for error.
R-squared = 69.17% Adjusted R-squared = 54.94% MSE = 384171.

Step 3:
Removing variable connectivity with F-to-remove =0.079177
5 variables in the model. 14 d.f. for error.
R-squared = 68.98% Adjusted R-squared = 57.90% MSE = 358903.

Step 4:
Removing variable road density with F-to-remove =1.68386
4 variables in the model. 15 d.f. for error.
R-squared = 65.25% Adjusted R-squared = 55.98% MSE = 375266.

Final model selected.

Table 9: Cochrane-Orcutt transformation applied: autocorrelation = 0.0

Parameter	*Estimate*	*Standard Error*	*T-Statistic*	*P-Value*
CONSTANT	-990.488	1461.43	-0.67775	0.5083
accessibility	6802.83	1695.7	4.01181	0.0011
supply	-296.575	83.1178	-3.56813	0.0028
demand	285.359	63.4553	4.49701	0.0004
location	266.984	119.619	2.23196	0.0413

Table 10: Analysis of Variance

Source	*Sum of Squares*	*Degree of freedom*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1.05701E7	4	2.64253E6	7.04	0.0021
Residual	5.62899E6	15	375266.		
Total	1.61991E7	19			

R-squared = 65.2512 percent; R-squared (adjusted for d.f.) = 55.9849 percent; Standard Error of Est. = 612.589; Mean absolute error = 395.632; Durbin-Watson statistic = 1.23421; Lag 1 residual autocorrelation = 0.292141

The output shows the results of fitting a multiple linear regression model to describe the relationship between Commercial Property Value and 8 independent variables. The equation of the fitted model is

*Commercial Property Value = -990.488 + 6802.83*accessibility - 296.575*supply + 285.359*demand + 266.984*location* ***...Eqn. 3***

Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant impact of the variables on commercial property values at 95.0% confidence level.

The R-Squared statistic indicates that the model as fitted explains 65.2512% of the variability in Commercial Property Value. The adjusted R-squared statistic, which is suitable for comparing models with different numbers of independent variables, is 55.9849%. The standard error of the estimate shows the standard deviation of the residuals to be 612.589, while the mean absolute error (MAE) of 395.632 is the average value of the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0.0413, belonging to location. Since the P-value is less than 0.05, that term is statistically significant at the 95.0% confidence level.

It may be deduced from the stepwise regression that location, demand, supply, accessibility in the absence of other explanatory variables of road network individually and jointly have statistically significant impacts on commercial property values using the stepwise regression model.

5.0 Conclusion and Recommendation

This study has shown that the graph-theoretic approach to road network analysis is useful for the determination of levels of accessibility in a community and should become useful tool for planners, valuers, and investors in deciding the best site for real estate development proposal. This study also has shown the impacts of the explanatory variables of road network in the presence of demand, supply, and location factors on commercial property values in the study area are significant. It is therefore recommended that Government at all levels should increase funding of road improvements including construction, maintenance, and rehabilitation of the entire arterial road network that delivers the accessibility. When commercial property values are enhanced, the amount of property tax to be derived would increase; and similarly, the revenue available for such road improvements would increase.

Also, it is recommended that the real estate practitioners, planners and property developers should consider accessibility, demand, and supply as important variables in the valuation of commercial properties in order to express opinions of values that are reliable. Lastly, the explanatory variables may not have equal degree of impacts on commercial property values; there is therefore opportunity for further research in terms of the relative contributions of each of them to variability in commercial property values. Also, further research would be required to account for 30.63% unexplained variability in commercial property values in the study area.

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