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MODELLING RURAL MARKET FREIGHT DISTRIBUTION IN SOUTH WESTERN NIGERIA

OJEKUNLE, J.A.,[1] ADEPOJU, O.O.[2] AND OWOEYE, A.S.[1]
[1]Department of Transport Management Technology, School of Entrepreneurship and Management Technology, Federal University of Technology, Minna, Nigeria
[2]Department of Transport Management, Faculty of Management Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
*Corresponding author: ojekun@yahoo.com

Abstract
A proper understanding of the freight flow in terms of their production and distribution is crucial to spatial development and planning of an area. This *study therefore, attempts to develop a model for estimating the distribution of rural freight generated in rural markets of South Western Nigeria. A questionnaire survey of commodities loaded and transported as well as rural freight operators in some rural market locations using systematic random sampling of 1 out of every 10 freight vehicles was carried out to determine their types, volume, origin and destinations of rural goods. Based on the data collected, a rural freight distribution model is developed using regression model. A logarithm method used for the data analyzed shows that out of three variables used, only two of them that is; the Cost of Transportation (CP) and Population of Destination of Goods (POP) are significant at 1% and 5% level respectively in explaining the variation in the rural freight distribution in the study area, while the Proximity of the Attracting State (PS) is not found to be significant. The three variables however accounted for 65% of the explanation of variation in the rural freight distribution in the South Western Nigeria. Based on these findings, it was recommended that deliberate policy measures should be put in place by the government to reduce the cost of rural goods transportation by improving rural road condition, enhancing rural market accessibility and rural goods operation.*

Key Words: *Rural freight, Distribution, Flow, Transportation, Modelling*

Introduction

The flow of traffic be it passengers and freight influences the landscape and socio-economic development of an area Michael (2008). A proper understanding of the freight flow in terms of their production and distribution is crucial to spatial development and planning of an area. The demand for freight is a factor that influences its production and distribution. The demand for freight transport especially at international level is also determined by a country's GDP and geographical area (Bennathan *et al*., 1992). On the other hand, it was observed that the general increase in freight transport especially road freight traffic in some developed countries is not as a result

of the new production method but it is caused by the liberalization of the transport sector which, results to extremely low transport cost (Strutynski, 1995). Rodrigues (2003), further argued that the increase in the flow of freight have been a fundamental component of contemporary changes in economic systems at global, regional and local scales. In addition, regional areal differentiation of places create localized surpluses that can be transferred to deficit areas and this agrees with the concept of complementarity (Ola 1978 and Ullman, 1956)

One of the major constraints of freight demand in rural areas is the size of the rural transport market, which largely depends on population densities. In general, Africa has low rural population densities and a less intensive form of agriculture than Asian countries. Additionally, markets are generally more distant and less accessible in Africa (Sieber, 2009). In Nigeria, demand for freight transport is influenced by the volume of industrial and agricultural production and attributes of transport modes available to the users (Alokan, 1995). However, Ogwude (1993) argued that the annual sales of the firm, vehicle ownership, freight charges, transit time, and reliability of delivery time are important determinants of modal choice of freight transportation in Nigeria.

At an urban market level, the demand for freight is considered to be influenced by the size of the market, in terms of patronage level of the buyers and sellers and the market proximity to the buyers and sellers (Ogunsanya, 1987). Sustainable rural developmental changes are a function of a number of factors in which transportation is of paramount. Efficient and effective rural transportation especially road, serves as one of the means through which rural goods are collected, consolidated and transferred to urban areas for consumptions thereby promotes rural economy (Adedeji *et al*., 2014). Most previous studies on freight transportation and distribution in developing countries particularly in Nigeria focused mainly on urban centres with little or no attention on rural freight distribution. This paper therefore tries to fill this gap by examining the factors that influence rural freight distribution flow from rural markets in the South Western Nigeria.

Conceptual Issues and Literature Review

Freight refers to goods and materials that are in transit or are loaded for transportation (Stopher and Meybury, 1975). They also referred to as consignment. The freight transported from rural markets in Nigeria are mainly agricultural goods which are purchased from farmers by dealers of agro-commodities, who in turn sell them either for domestic or industrial consumptions in the cities. Freights are classified into various groups depending on their types and nature. Freight vehicles on the other hands, according to Stopher and Meybury (1975) are defined as those that are wholly or largely purchased for the carriage of goods. These include articulated Lorries whose capacities are determined by the size of the carrying units and the nature of the routes. However, Alokan (1988) observed that this definition of a freight vehicle is somewhat arbitrary. He argued that the potential for joint carriage of both passenger and freight in one vehicle prevents any rigorous or exclusive delineation of passenger and freight vehicle.

The types of vehicles used in freighting can be classified into two; these

are the lorries and trailers. Technically, the types differ in terms of their size and whether or not the motive power unit is physically combined with the cargo unit. The lorry constitutes a total transport unit as the cargo unit is combined with the motive power unit. This limits the size of the cargo it can carry. The axle loads of these Lorries range from 3 to 10 tons (Alokan, 1988).

The trailers (or articulated vehicles), on the other hand, have their engines separated from the cargo unit and so variability of capacity can be achieved. Trailers can be further classified into four types according to the type of freight they are specially designed to carry (Alokan, 1988). These are "sided", "flat" trailers, liquid tank truck (commonly referred to as tankers) and the dry bulk carriers. The sided vehicle refers to those whose cargo units have rail-guards on either side, while the "flat" ones do not have rail guards.

Several factors influence the allocation of freight to the Lorries or trailers. Some of these include the volume of the freight, the type of freight involved, the nature of the road and the distance between the origin and destination of goods (Alokan, 1988). Ogunsanya (1981) observed that Lorries are more suitable for intra-urban movement while trailers are best for long distance freight movement. Various factors have been identified as reasons for non-suitability of trailers in urban freight transport; these include the size, weight, length and height of trailers. Similarly, these trailers are also unsuitable in rural areas because of the narrow and winding nature of most rural roads (Ojekunle, 2006). The freight locations are also dispersed and the volume in each location is usually small for a trailer load (Oluwole *et al*., 2016).

Apart from lorries and trailers, there are other types of vehicles being used for freight transportation in rural areas in Nigeria, these include 'pickups, vans, buses, taxis, trucks and motorcycles. All these means of transportation are used for carriage of both passengers and freight simultaneously. This is why they cannot be exclusively defined as wholly freight vehicles.

For analytical purposes, food production-distribution systems (or simply, food systems) have been defined and subdivided into three levels of focus: farm or firm level, channel level, and general system level (Kelly *et al*., 1975). The channel level of analysis identifies a set of farms and marketing firms which perform value-adding processes through a closely linked sequence. The channel level of analysis may be carried out at a specific commodity or more general food distribution subsystem level. In these cases, subsystem studies are undertaken which shift the focal point of analysis from farm and marketing firms acting as individuals, to one of them acting as a relatively close group, exchanging information, products, and services in order to satisfy final channel demand. Marion has defined two important variables of interest in subsystem studies.9

The structure and pattern of rural freight attraction and distribution are diverse in Nigeria. Musa (2009), pointed out that in Nigeria, agricultural produce constitute a significant percentage of commodities of inter-regional trade transported by road, he listed some of these agricultural commodities as potatoes, tomatoes, vegetables, fruits, Others are cattle, sheep, and goats, grains, cereals, tubers, and nuts to mention only a few. The development of rural logistics and distribution has an important

significance to the development of rural area in China (Huang *et al*., 2012). According to Huang *et al*. (2012) obsolete rural logistic system and delay in transportation are major problem of rural logistics and distribution of agricultural products in China.

There are different types of transportation models, ranging from spatial, economic, or econometric to linear and mathematical models. Whichever type of model being developed, modeling goes through basic steps. Modelling in transportation studies therefore, evolves through three basic processes; these are model specification, quantification and calibration. These processes form the basic steps taken in developing transportation model. The processes form the basic steps adopted in modeling rural freight distribution in this study (O'Flaherty, 2003).

Methodology

The South western Nigeria, which is the study area comprises of six states namely: Lagos, Oyo, Ogun, Ondo, Osun and Ekiti States. Out of these six states, three of them were purposively selected namely; Oyo, Ondo and Ogun. Their selection was justified on the ground of their rurality, distinct vegetations, number of rural markets located in them, and the diversity of their agricultural produce. Oyo State has the largest number of rural markets with a distinct vegetation type mainly of Guinea Savannah. Ogun State, bounded by Lagos in southern part comprised of mangrove and equatorial rainforest with numerous rural markets. Ondo was considered because of its dominance in the production of cash crops such as plantain, cocoa, palm produce, and other cash crops like cola nuts which is predominantly an equatorial rainforest. These three states were therefore selected with the assumption that whatever data obtained from them would be a good representation of the entire region. Lagos was however not considered because of its cosmopolitan nature. Most of its markets are not really rural but more of urban in nature which is at variance to the aim of this study.

In order to collect Information on the number, names and location of rural market centres in the study, local newspapers that provide information on rural markets (i.e. "Iroyin Yoruba", "Isokan", "Akede" "Gboungboun" etc) were consulted. These local newspapers usually carry reliable information on the number of existing rural markets in the south Western Nigeria and the days of their operation. From the review of the local newspapers and State Annual Economic Reports collected from ministries of rural development in the three states selected, a total of 248 rural market centres excluding the markets located in the urban centres were identified in the study area.

The next stage was the selection of rural markets among the sampled states. There are two issues involved here. The first is the determination of the sample size since all the markets cannot be surveyed. The second is the choice of the actual markets to be surveyed. In respect of the first one, a 10% sample was deemed appropriate. Previous works such as Fadare (1992) lend credence to this sample size. For the choice of the actual market, a systematic random sampling procedure was adopted. This was done by assigning number to all the rural markets identified in each State, one out of every ten markets in each state was then selected as a sampled rural market. By doing this, ten (10) rural markets were selected in

Oyo state, 8 were selected in Ogun state and 7 were selected in Ondo state making a total of 25 sampled rural markets. Figure 1 shows the map of the study area, the location of rural market centres and the sampled rural markets.

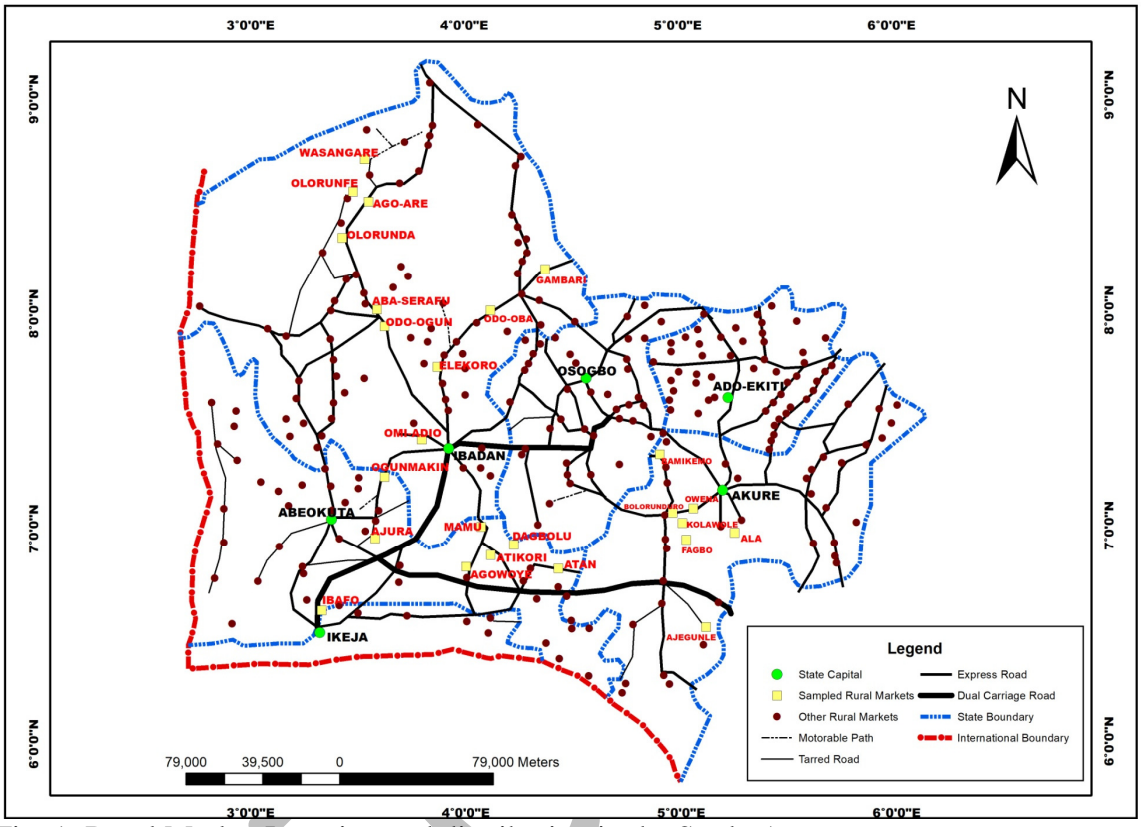

Fig. 1: Rural Market Location and distribution in the Study Area

A total of 915 questionnaires were administered, but after sorting the defective ones, only 887 transport operators' questionnaires were used for analysis. SPSS computer package version 16.1 was used to analyze the data collected with the application of regression analysis for developing spatial rural freight distribution model. For estimating freight volume, different commodities loaded by each vehicle at the markets were counted and recorded by field assistants which were subsequently multiplied by the "standard weights" adopted by the authors to arrive at a total volume of goods transported by different categories of vehicles from the markets to different destinations. The term "standard weight" in the context of this study refers to the weight resulting from the average weight of randomly sampled related commodities. The standard weight is obtained by weighing different measures of agricultural produce on weighing scales and converting them all into single unit of measurement (i.e tons).

Multiple regression model was used in the analysis of the data. This implies that certain factors help to explain freight distribution by rural markets. It can therefore be conceptualized that there is a set of variables x_1, x_2, x_3,.....xn which can be used to explain the volume of goods distribution from different rural markets in

South Western Nigeria. This may be mathematically stated as

$y = f(x_1, x_2, x_3, \ldots\ldots x_n)$.....(1)

This can be transformed using the multiple regression equation thus:

$Y = a+b_1x_1+b_2x_2+b_3x_3\ldots xb_n\ xn+e$....(2)

Where Y = the dependent variable, that is the volume of goods distributed to different distant destinations

a = constant

$b_1, b_2, b_3, \ldots\ldots b_n$ = the intercept

$x_1, x_2, x_3, \ldots\ldots x_n$ = the independent variables

e = error term (representing the unexplained variables).

The multiple regression model is a useful statistical tool for finding the contribution of independent variables to dependent variables. The statistics produce a coefficient of determination which is a measure of the total contribution of the explanatory variables to the dependent variable. The equation results provide a basis for predicting the value of dependent variable from two or more independent variables. For the purpose of this study, the multiple regression is operationalised as follows:

RFD = f(PS, POP, CT,)----------eqn. (3)

Where

PS = Proximity of the attracting State of the sampled rural market centre

POP = The estimated population of individual State attracting goods

CT = Average cost of transportation of goods per ton per kilometer

RFD = Volume of freight attracted to individual states

This is therefore transformed as $RFD = a + b_1PS + b_2POP + b_3CT$----------eqn. (4)

Result and Discussion

In freight modeling, the first step usually taken is to carry out a diagnostic correlation analysis of the selected variables in order to check for the level of multicollinearity among the dependent variables. The result of the correlation analysis done is presented in Table 1 below.

Table 1: Correlation Coefficient of Dependent and Independent Variables

	(Y) (RFD)	X1 (PS)	X2 (POP)	X3 (CT)
Y (RFD)	1.00			
X1 (PS)	-.576	1.00		.
X2 (POP)	.292	-.297	1.00	
X3 (CT)	-.620	.905	-.316	1.00

The table reveals that all the three independent variables are correlated with the dependent variable. In terms of direction of relationship, two of them are negative, which implies that an increase in the value of X1 and X3 leads to a decrease in the values of Y The relationship is not unexpected. In case of X1, several studies have earlier confirmed that distance between generating and attracting point is inversely related to the volume of interaction between them (Isard 1972). On the other hand, the cost of movement also affects negatively the volume of goods that will be transported from one origin to a destination. For example, the higher the cost of moving a ton of goods on a kilometre of road, the lower will be the volume of goods that will be transported. Although, X2 is not strongly correlated with Y variable, the direction of relationship is positive, which implies that

as the value of X2 variable increases, the value of Y variable also increases. The result also conforms to the established law, which says the population of attracting point is positively related to the volume of interaction attracted to that attracting point (Isad, 1972). However, there is strong correlation between X_3 and X_1. This implies that the distance of haulage is highly related to cost of transportation, this also conforms to the reality. In an attempt to run regression analysis, the data were subjected to multiple linear regression However, in order to improve data performance, the data were transformed in to logarithm. The results of the logarithm transformed data are provided in Table 2.

Table 2: Results of Regression Analysis for Goods distribution

INDEPENDENT VARIABLES	DEPENDENT VARIABLE (RFD)	LOG OF (RFD)
Constant	1412.4	11.05
	(2.31)	(1.80)
PS	-0.03	
	-0.02	
LPS		-0.24
		(-0.53)
POP	.00001	
	(1.06)	
LPOP		0.65**
		(2.02)
CT	-0.12***	
	(-1.63)	
LCT		-1.59*
		(-2.51)
R^2	0.43	0.71
R^2 Adjusted	0.31	0.65
'F'	3.53	11.35
N	18	18

't' values are in parenthesis, * significant at 1% level,** significant at 5% level, ***significant at 10% level

The empirical results presented in Table 2 shows without logarithm transformation of the data, only CT (i.e the Cost of Transportation) is significant at 10% confidence level in the determination of rural goods distribution in the Study Area. The negative sign indicates that reduction in the cost of transportation of rural goods will likely increase the quantity of goods that would be attracted to destination states. With the transformation of data into log, the result of analysis was greatly improved. The result shows that both LCT (i.e The Log of Cost of Transportation) per ton kilometer and LPOP (i.e The Log of Population of Attracting State) that is the population of state attracting the goods are significant at 1% and 5% level respectively. The model estimates is therefore; RFD = 1.80 - 0.24LPS+0.65LPOP -1.59LCT.

From the above analysis, one could see that cost of transportation of goods measured in naira and proximity to state measured by distance are major determinants of rural freight distribution in the study area. In terms of their contribution to the explanation of the

variation in the inter-state goods distribution, the three variables account for 65% explanation of the variation. The variables are therefore goods for modeling rural goods distribution in the area and they can be regarded as the major determinants of rural goods distribution in the area of study.

Recommendation

The findings from this study have some implications for policy makers particularly in the area of rural transportation and regional economic planning. As could be seen from the study, the cost of transportation is a major determinant of rural freight distribution, it is therefore necessary that deliberate policy measures should be put in place by the government to reduce the cost of rural goods transportation by improving rural road condition, enhancing rural accessibility and rural goods operation.

The linear distance between rural production centres (rural markets or farm centres) may not be reduced but providing good roads, efficient transportation and distribution system of rural goods will go along to reduce cost of rural goods transportation and distribution. If that happens, more rural goods will be efficiently distributed from the study area to other parts of Nigeria.

Standardizing rural data into single unit of measurement was a major problem encountered by the researcher. Therefore, there is also the need to introduce standardized measures for rural goods packaging and loading so that uniform unit of measurement can easily be applied on different categories of goods produced in the rural areas. This will facilitate data collection on rural goods and allow ease comparison of data on freight flows. Finally, more research is required on identifying other determinant factors that could influence rural goods distribution not only in the study area but in the entire country.

Conclusion

The study has provided useful information on the spatial flow of rural freight in the South Western Nigeria. The major constraints and determinants of rural freight distribution have been identified and the policy actions needed to ensure effective and efficient rural freight distribution have also been highlighted. It is believed that if those policy actions are considered for implementation they will no doubt enhance rural economic growth and development of the country.

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