Logit modeling of travel mode choices in some selected villages of Ifedore local government Ondo State Nigeria

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ABSTRACT: This paper formulates a logit based model of travel choice that accommodates variations in mode preferences and responsiveness to level of service due to both observed and unobserved individual characteristics. Primary data was gathered using stratified sampling technique with Ilara- Mokin, Ijare, Igbara- Oke, Ibule and Owena-Ijesa systematically selected as strata for the entire study area. The method of data collection includes face-to-face structured or semi-structured interviews, while questionnaires were handed out at transport nodes. Observation of secondary data was also used to assess the socio-economic characteristics and the level of service and availability of transport service for the villages. The data were regressed to obtain the utility equation and then analysed using binary logit modeling technique. The proportion of trips made by motorcycle for Igbara-oke, Owena, Ilara-mokin, Ibule and Ijare are 89.84%, 88.22%, 69.69%, 88.08% and 85.23% respectively; while 10.16%, 11.78%, 30.31%, 11.92%, and 14.77% respectively are the proportion of trips made with commercial vehicle. The highest numbers of trips were to Owena-owode, this is attributed to the popular Owena market. Also, the value of the coefficient of determination shows that the utility equation derived do not have biased coefficient Thus, from the derived model it shows that people derive satisfaction in using motorcycle as preferred mode. The result of this analysis will help in estimating the competitive mutually exclusive travel demand and temporal distribution across different travel pattern in the study area.

Keywords: Logit-model, Travel-Choice, Stratified Sampling, Mode-Share, Socio- Economic, Binary Logit and Temporal Distributions

INTRODUCTION

The mode choice is used to estimate future travel volumes by modes, this step is based on the concept that the mode-choice behavior of trip makers can be explained generally by three categories of factors viz-a-viz the characteristics of available modes; the socio-economic status of the trip maker; and the characteristics of the trip(Papacostas and Prevedouros, 2005). Mode choice models are classified into two groups according to the type of mathematical abstraction used, namely the aggregate models and the disaggregate behavioral models. Statistical data are mainly considered in aggregate models, and for the latter the individual utility measures are considered. The aggregate

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models are differentiated according to the sequential procedure in which each model is applied while the trip-end mode choice model is processed just after the trip generation step. Also, the trip interchange mode choice model is executed after the trip distribution model.

In disaggregate behavioural models the term 'disaggregate' means that the models are based on individual observations and the term 'behavioral' means that they reflect the actual choice process level on which the choice is made. A behavioural model is defined as one which represents the decisions that consumers make when confronted with alternative choices; according to Ben Akiva and Lerman (1985), the individual is visualized to select the mode with maximum attraction, due to various attributes, such as in-vehicle travel time, access time to the transit point, waiting time for the mode to arrive at the access point, interchange time, travelling fares and parking fees among others. However, the models that tend to represent the travel behaviour of the individuals when provided with a discrete set of travelling alternative are commonly referred to as discrete choice models. The utility function measures the degree of satisfaction that people derive from their choices for a specific trip; therefore, the utility is generally represented as a linear function of the attributes of the journey weighted by the coefficients which attempts to represent their relative importance as perceived by the traveler. A possible mathematical representation of a utility function of a mode \( m \) is shown in equation 1.0 as:

\[
U_{mi} = \theta_1 X_{mi1} + \theta_2 X_{mi2} + \ldots + \theta_K X_{mik} \quad \quad \quad \quad \quad 1.0
\]

where:

- \( U_{mi} \) is the net utility function for mode \( m \) for individual \( i \)
- \( X_{mi1}, \ldots, X_{mik} \) are \( K \) no of attributes of a mode \( m \) for individual \( i \)
- \( \theta_1, \ldots, \theta_K \) are \( K \) no of coefficients (or weight attached to each attributes)

Also, the choice behaviour can be modelled using the random utility model which treats the utility as random variable; that is, comprising of two distinctly separable components; a measurable conditioning component and an error component as given in equation 1.1 below.

Therefore: \( U_{mi} = V_{mi} + E_{mi} \quad \quad \quad \quad \quad 1.1 \)

where:

- \( V_{mi} \) is the systematic component (observed) of utility of mode \( m \) for individual \( i \) and \( E_{mi} \) is the error component (unobserved) of utility of mode \( m \) for individual \( i \)

Several models are used in the area of transportation planning. Some of these models are the Logit model; Binary logit model, Multinomial logit model and Nested logit model. Logit model possess the ability to model complex travel behaviors of any population with simple mathematical techniques. The mathematical framework of logit models is based on the theory of utility maximization; presenting the framework, the probability of an individual \( i \) selecting a mode \( m \) out of \( M \) number of total available mode is given as

\[
P_{im} = \frac{\exp(V_{in})}{\sum \exp(V_{mj})} \quad \quad \quad \quad \quad 1.2
\]

where:

- \( P_{im} \) is the probability that alternative \( n \) will be selected by individual \( i \).
- \( V_{in} \) is the utility function of mode \( n \) for individual \( i \)
- \( V_{im} \) is the utility function for the modes \( m \) in the choice set for individual \( i \)

Theoretical frame work of logit models is based on the three main assumptions regarding the error term \( \varepsilon m \) as shown in equation 1.2. The assumptions are \( \varepsilon m \) is Gumbel distributed, \( \varepsilon m \) is independently distributed and \( \varepsilon m \) is identically distributed. All these three assumptions serve as the main postulates of the structure of logit models. The first assumption of the random component being Gumbel distributed indicates that all the utilities associated with the travelling mode should be considered as a linear sum of attributes and has the same scale parameter (Ben Akiva
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and Lerman 1985). The last two assumptions are normally grouped together to be referred to as a property of independence of irrelevant alternatives (IIA property) simply meaning that all travel modes are generally classified into main categories namely Binary and Multinomial logit models. Binary choice models are capable of modeling with two discrete choices only; that is, the individual having only two possible alternatives for selection, whereas the multinomial logit models imply a larger set of alternatives.

The mathematical framework of a binary logit model is a simplified representation of equation 1.2 with the total number of available alternatives limited to two; that is, M = 2. Simplifying equation 1.2, the probability of individual I selecting the mode m out of two available travelling mode m and n is given as

\[ P_{im} = \frac{\exp(V_{im})}{(\exp(V_{im}) + \exp(V_{in}))} \]

or

\[ P_{im} = \exp\left[\frac{1}{1 + \exp(V_{in} - V_{im})}\right] \]

\[ P_{in} = 1 - P_{im} \]

where:

- \( V_{im} \) is the utility function associated to alternative m for individual i;
- \( V_{in} \) is the utility function associated to alternative n for individual I;
- \( P_{in} \) is the probability that alternative n will be selected by individual i.

Also, \( U_i = V(X_i, S) + E_{i} \), ............................................ 1.4

where:

- \( U_i \) is the utility of alternative i
- \( V \) is the systematic (observed) component of the utility function
- \( E \) is the error component of the utility function
- \( X_i \) is the vector of observed attributes of alternative i; and
- \( S \) is the vector of observed characteristics of the individuals of the study area.

The transport planners generally prefer using logit models as they possess simple mathematical framework and can accurately model the travel behaviour of a study area. Gharieb (1996) compared logit with probit models using them to estimate the travel behaviour for different cities of Saudi Arabia and concluded that the Logit models are superior to their probit counterparts in terms of goodness-of-fit measures and tractable calibrations. Dow and Enders (2004) supported his findings by concluding that Logit model should always be preferred over Probit models and the latter should only be utilized if the travel behaviour of the targeted population to be determined is observed to be complexly complicated. Thus, the research work will examine the available travel modes and its operation, and develop logit models of travel mode choices for some selected rural areas of Ifo local government in Ondo state.

The Study Area

Ifo Local Government with her headquarters in Ibara-Oke, is one of the local governments in Ondo State, Nigeria. It has an average temperature ranging from 27°C to 30°C and a rainfall approximately 1450mm per annum. It is about 250m above the sea level and is located in the forest zone with abundant forest resources. According to the 2006 - National Population Census; it has a population of 176,372 with 89,574 males and 86,798; the Local Government is noted for its significant agricultural activities. The towns/villages under Ifo Local Government are Ijare, Bolorunduro, Ibufi, Ibara Oke, Ilara Mokin, Ibara Odo, and Owena, among others as shown in Figure 1.1. Across these towns, few industries and tertiary educational institutions are present. Among which are All States College of Education, Elizade Polytechnic, SCC Construction Company, and some Commercial Banks while Land transportation serves as the major mode of transportation in Ifo Local Government. The existing land use is
characterized by a medium density of residential structures within the inner core areas and predominantly farming in the outer core areas. There are quite a good number of open spaces and virgin lands with a general lack of recreational areas except for few school playing fields.

![Map of Akure Showing the Study Areas](image)

**Figure 1: Map of Akure Showing the Study Areas**

**Source:** Ifedore Local Government Area of Ondo State (2009)

**MATERIAL AND METHODS**

Primary data was gathered through the use of a questionnaire survey; stratified sampling technique was used in survey process administration with Ilara- Mokin, Ijare, Igbara- Oke, Ibule and Owena-Ijesa systematically selected as strata for the entire study area. The method of data collection includes face-to-face structured or semi-structured interviews, while questionnaires were handed out at transport nodes. Observation of secondary data was also used to assess the socio- economic characteristics and the level of service and availability of transport service for the villages. The data were regressed to obtain the utility equation and then analysed using binary logit modeling technique.
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RESULTS AND DISCUSSION

The results of the modal split were presented as follows:

**Modal split model for Igbara-Oke**

Pr (motorcycle) = \( \frac{\exp(U(\text{motorcycle}))}{\exp(U(\text{motorcycle}))+\exp(U(\text{commercial vehicle}))} \)

Pr (private car) = \( \frac{\exp(U(\text{private car}))}{\exp(U(\text{motorcycle}))+\exp(U(\text{commercial vehicle}))} \)

Pr (private car) = \( \frac{6.49 \times 10^{-3}}{6.49 \times 10^{-3} + 5.267 \times 10^{-2}} \) = 10.16%

Pr (motor cycle) = \( \frac{5.367 \times 10^{-2}}{6.49 \times 10^{-3} + 5.267 \times 10^{-2}} \) = 89.84%

Similarly, the modal splits were also computed for the other strata and the result is presented in Table 1 below. While the proportion of the motorcycle and commercial vehicle are depicted in Figures 2 and 3.

![Figure 2: Proportion of Trips by Motorcycle in the Study Area](image-url)

Figure 2: Proportion of Trips by Motorcycle in the Study Area
**Figure 3: Proportion of Trips by Commercial Vehicle in the Study Area**

<table>
<thead>
<tr>
<th>Villages</th>
<th>Total No. of Trips per week</th>
<th>Motorcycle</th>
<th>Commercial Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Igbara Oke</td>
<td>19,112</td>
<td>17,170 (89.84%)</td>
<td>1,941 (10.16%)</td>
</tr>
<tr>
<td>Owena</td>
<td>33,504</td>
<td>29,557 (88.22%)</td>
<td>3,947 (11.78%)</td>
</tr>
<tr>
<td>Ilara-mokin</td>
<td>21,645</td>
<td>15,084 (69.69%)</td>
<td>6,560 (30.31%)</td>
</tr>
<tr>
<td>Ibule</td>
<td>15,928</td>
<td>14,029 (88.08%)</td>
<td>1,899 (11.92%)</td>
</tr>
<tr>
<td>Ijare</td>
<td>14,106</td>
<td>12,023 (85.23%)</td>
<td>2,083 (14.77%)</td>
</tr>
</tbody>
</table>

**Model Summary for the Transport Mode**

The probable utility function for motorcycle and commercial vehicle at the selected villages were derived using a linear combination of the variables and were regressed using SPSS (2006). The utility equations are presented in Table 2.

**CONCLUDING SUMMARY**

From the analysis, the proportion of trips made by motorcycle for Igbara-Oke, Owena, Ilara-mokin, Ibule and Ijare are 89.84%, 88.22%, 69.69%, 88.08% and 85.23% respectively; while 10.16%, 11.78%, 30.31%, 11.92%, and 14.77% respectively are the proportion of trips made with commercial vehicle. However; highest numbers of trips were to Owena-Ijesa, this is attributed to the popular Owena market (a commercial nerve centre in the local government area). Also, the value of the coefficient of determination shows that the utility equation derived do not have biased coefficient Thus, from the derived model it shows that people derive satisfaction in using motorcycle as preferred mode. It should be noted that transit - captive users have no volition as the change in the trip attributes does not affect their choice.
Table 2: Model Summary Utility Equations for the Selected Villages

<table>
<thead>
<tr>
<th>Village</th>
<th>Mode</th>
<th>Utility Equation</th>
<th>Coeff. of Correlation “R”</th>
<th>Coeff. of Determination “R²”</th>
<th>Adjusted “R²”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Igbaro-oke</td>
<td>Motorcycle</td>
<td>$U = 0.304x_2 - 0.154x_3 - 0.116x_1 + 0.096$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Commercial vehicle</td>
<td>$U = 0.194x_2 - 0.056x_3 - 0.007x_1 + 0.0394$</td>
<td>0.998</td>
<td>0.997</td>
<td>0.997</td>
</tr>
<tr>
<td>Owena</td>
<td>Motorcycle</td>
<td>$U = 0.114x_2 - 0.076x_3 - 0.079x_1 - 0.273$</td>
<td>0.986</td>
<td>0.972</td>
<td>0.971</td>
</tr>
<tr>
<td></td>
<td>Commercial vehicle</td>
<td>$U = 0.209x_2 - 0.124x_3 - 0.052x_1 - 0.053$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Ilaramokin</td>
<td>Motorcycle</td>
<td>$U = 0.589x_2 - 0.329x_3 - 0.061x_1 - 7.6899$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Commercial vehicle</td>
<td>$U = 0.071x_2 - 0.929x_3 - 0.144x_1 - 0.08404$</td>
<td>0.966</td>
<td>0.933</td>
<td>0.927</td>
</tr>
<tr>
<td>Ibule</td>
<td>Motorcycle</td>
<td>$U = 0.478x_2 - 0.182x_3 - 0.238x_1 + 0.014$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Commercial vehicle</td>
<td>$U = 0.366x_2 - 0.117x_3 - 0.013x_1 + 0.0127$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Ijare</td>
<td>Motorcycle</td>
<td>$U = 0.0296x_2 + 0.00038x_3 - 0.1208x_1 - 0.01$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Commercial vehicle</td>
<td>$U = 0.701x_2 - 0.055x_3 - 0.064x_1 - 0.09$</td>
<td>0.796</td>
<td>0.634</td>
<td>0.616</td>
</tr>
</tbody>
</table>

REFERENCES


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