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Stated Preference Modeling for a Preferred Transportation Mode

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ABSTRACT

This paper contains econometric analysis of commuters' behaviour with regards to their choice between different transportation modes (car and bus) in traveling to Accra central. Using the data collected from an experimental survey, a binary logit model and its marginal effects was estimated. The magnitude of estimates generally indicates that bus users highly value attributes such as price and habit. However, the level of noise, comfort, and time (morning trips) will result in a disutility of public transport choice.

Keywords: Commuters, discrete choice model, mode choice, public transport, stated preference

1.0 INTRODUCTION

Public transport in many developing countries started in early 18th century and the companies were controlled by the state. In Ghana, road transport is the predominant means of travelling, which enhances high passenger travels and carting of goods and services. It provides essential role by linking the country to others in the entire West African sub-region. In fact public transport has developed rapidly in Ghanaian societies, but there is competition between privately owned cars and buses on our roads which has contributed to longer shuttling period and journey delays, high accident rates, and localized poor air quality (Afful, 2011). It is obvious that public transport competes with other modes of transport and will be used only if it can satisfy the expectations of passengers, that is, if it can offer an attractive, reliable, affordable, and safer service (Stradling, Carreno, Rye, & Noble, 2007; Currie, 2005). However, as a result of the poor quality of travel in public transportation systems in Ghana with a resulting declining trend in passengers' choice of buses, policy-makers and transport operators are constantly in search of solutions for improving bus choice, especially in urban areas of developing countries (Accra, for example). However, the author is of the view that an increase in bus use with a concurrent reduction in the use of private cars could help to reduce many problems like traffic congestion, air and noise pollution, and energy consumption. For these reasons, several works have been made by various studies on urban public transport; for example, Van der Waerden et al. (2007) used Multinomial logit model to examine the choice between car, bus and bicycle for different journey purposes. They argued that the cost and time attributes dominate, obtaining a seat is significant across journey purposes. Alpizar and Carlsson (2001) examined mode choice between bus and car, with improved bus quality as one of the attributes. Multinomial logit and Random parameter logit models were employed. The authors concluded that the best means of attracting passengers is to decrease the bus journey time. Pavlyuk and Gromule (2010) in their study considered three possible transport options; car, coach, and train. A nested discrete choice model was used to analyze factors that influence passenger's choice. The authors concluded that departure time had a significant influence on bus or train choice. Passengers who choose price as a key factor in their selection prefer to use the train. Catalano, Lo Casto and Migliore (2008) employed random utility model to analyze travel mode choice behaviour for commuting urban trips in Palermo, Italy. The authors found outthat for the specific case of Palermo, the Multinomial logit proved to be the best urban transport demand model, even if the choice set contained three car alternatives. However, most of the studies are carried out in developed countries with paucity of information on commuters' attitude when they have an option of using a private car and public transport going to work. According to Damaraju, James and Pallavi (2011), in real life situation, people reveal their preferences through choices, and that the aggregate of choices constitute the demand for goods and services. However, understanding how changes in the characteristics of alternatives affect preferences for them, is important in many fields (i.e. transportation) in which predicting human choices are of interest. In this research, we constructed a discrete choice model which is rooted in Random Utility Theory (RUT) for predicting the preferred transportation mode when commuters are traveling to the central district of Ghana's capital city (i.e. Accra Central). Stated/discrete choice model enables the prediction of choices made by respondents/individuals among a range of attributes. In the research a wide range of attributes/attribute levels that could influence passengers' choices were investigated and revealed. The ways these attribute levels affect passenger choice can be used to improve or design policy issues that could minimize the use of private cars to reduce traffic/road congestion in Accra.

2.0 METHODOLOGY

2.1 Approach

The development of utility models on the basis of user preferences collected in the form of either Stated Preference (SP) or Revealed Preference (RP) data is necessary. RP and SP data have been used in diverse fields for estimating various attributes (Adamowicz, Louviere, and Williams, 1994; Hensher, 1994; Jose Holgium-Veras, 2002). However, RP data are used to observe actual behaviour, rather than asking respondents how they would behave in a hypothetical situation. According to Ortúzar and Willumsen (1994), the basic shortcomings of SP surveys are not present in RP surveys as they deal with existing actual situations being experienced by the user. SP data may be collected in the form of rating, ranking, and choice. However, Stated Choice (SC) method has strong theoretical foundations based on economic theory and is an established approach for understanding and predicting consumer trade-offs and choices in marketing research. SC experiments provide a frame work where one can study the relative marginal disutility of variations in attributes and their potential correlations (Louviere, Hensher, and Swait 2000). SC methods are widely used to model the attitude of respondents (Carlsson, Frykblom, and Liljenstolpe, 2003; Hensher, 2001; Hensher and Greene, 2001; Hensher and Sullivan, 2003). SP and/or RP data are commonly analyzed using logit models. However, this study uses a random utility model in the form of binary logit to capture commuter's preferences when they have a mode of choice between using a bus and using a car (the choice is not applicable when the commuter does not have access to a private car). The Maximum Likelihood Estimation (MLE) method was used to estimate the binary logit model.

2.2 Choice Experiment Design/Survey

In the stated/choice experiment, a number of attributes and assigned levels are used to generate hypothetical scenarios. Binary choice pairs (Bus andCar) are considered, and each choice pair has five common attributes. For each attribute, we adopt a two-level design. SPSS was used to construct eight profiles taking into account the condition of optimality. Kuhfeld (2010) opined that a design that is optimal is both balanced and orthogonal. These profiles were combined into 28 choice sets, and each respondent was asked to select the most preferred transport mode; using bus and using car when traveling to Accra central. Data were collected from 181 individuals who owned private cars and have access to buses. Hensher et al. (2005) asserted that a total sample of 50 individuals each with 16 choice sets and fully generic parameter specification for design attributes and covariate effects might just be acceptable for choice experiment. However, respondents were intercepted while at shopping centers and at offices spread over the area of Accra central. The attributes and corresponding levels used in this study were decided following discussions with experts and passengers. Adamowvic et al. (1998) opined that attributes are commonly identified from prior experience, primary or secondary research. Table 1 and Table 2 show the attributes and attribute levels, and choice sets used in the survey questionnaire.

Table 1: Attributes and corresponding levels

Attributes	Attribute Levels
Price	Yes
	No
Comfort	Agree
	Disagree
Noise Level	Very low/no noise
	High
Time	6am- 9am
	3pm-6pm
Habit	Agree
	Disagree

Table 2: Example of a labeled choice set submitted to commuters

Attribute	Bus	Private Car
Price	Yes	No
Comfort	Disagree	Agree
Noise Level	Very low/no noise	High
Time	3pm-6pm	6am-9am
Habit	Yes	No
Which transport mode would you choose?	**Bus [ ]**	**Private Car [ ]**

2.3 Econometric Model

Based on the framework of Random Utility Theory (McFadden, 1974), we assume that utility from transport mode choice can be characterized by a function:

$$U_{ci} = \alpha + \sum_{k-1}^{K} \beta_k X_{cki} + \sum_{m-1}^{M} \gamma_m Z_{mi} + \sum_{k-1}^{K} \sum_{m-1}^{M} \delta_{km} X_{cki} Z_{mi} + u_{ci} \qquad (1)$$

Where transport mode choice $c = \{B = Bus,\ A = Car\}$ and $i = 1...N$ refers to individuals, X is a vector of K attribute levels, and Z is a vector of M personal characteristics. The parameter β_k refers to the utility associated with transport mode attribute k and the parameter δ_{km} measures how this utility varies by a specific characteristic of the individual. The term u_{ci} is random and represents unobservable influences on individual choice. The framework assumes that the individual chooses the transport mode which generates more utility. The utility gain from transport mode $B = Bus$ over transport mode $A = Car$ for individual i is:

$$U_{Bi} - U_{Ai} = \sum_{k-1}^{K} \beta_k \left(X_{Bki} - X_{Aki} \right) + \sum_{k-1}^{K} \sum_{m-1}^{M} \delta_{km} \left(X_{Bki} - X_{Aki} \right) Z_{mi} + \left(u_{Bi} - u_{Ai} \right) \qquad (2)$$

The random component u_{ci} may be hypothesized to consist of three additive components; an individual specific component v_i, mode choice specific component e_c and a true iid random term. Of these, the individual specific term cancels out. The transport mode specific component can be assumed to be zero, unless the respondents have a consistent tendency to be more or less likely to respond to transport mode A instead of B. Suppose the individual chooses transport mode B if $U_{Bi} - U_{Ai} > 0$. This takes place with the probability

$$P\left[U_{Bi} - U_{Ai} > 0\right] = P\left[\sum_{k-1}^{K} \beta_k \left(X_{Bki} - X_{Aki} \right) + \sum_{k-1}^{K} \sum_{m-1}^{M} \delta_{km} \left(X_{Bki} - X_{Aki} \right) Z_{mi} + \left(u_{Bi} - u_{Ai} \right) \ > 0 \right]$$

$$= P\left[\left(u_{Ai} - u_{Bi} \right) < \sum_{k-1}^{K} \beta_k \left(X_{Bki} - X_{Aki} \right) + \sum_{k-1}^{K} \sum_{m-1}^{M} \delta_{km} \left(X_{Bki} - X_{Aki} \right) Z_{mi} \right] \qquad (3)$$

Assuming a distribution for $\left(U_{Ai} - U_{Bi}\right)$, for instance a logistic distribution, the probability in (3) can be expressed in terms of a logistic cumulative distribution and modeled accordingly with logit:

$$P\left[U_{Bi} - U_{Ai} > 0\right] = F\left[\sum_{k-1}^{K} \beta_k \left(X_{Bki} - X_{Aki}\right) + \sum_{k-1}^{K}\sum_{m-1}^{M} \delta_{km}\left(X_{Bki} - X_{Aki}\right) Z_{mi}\right] \quad (4)$$

Where $F\left(x\right) = \dfrac{e^x}{1+e^x}$.

This paper estimates equation (4) with a binary logit model where the levels of the transport mode choice attributes are treated as separate dummy variables in the regression analysis. The response variable (transport mode choice) is assigned 1 if public transport (bus) is chosen and 0 if a car is chosen.

3.0 RESULTS AND DISCUSSION

The result reported in Table 3 reveals that there is goodness-of-fit of the model from the data. The likelihood ratio chi-square of 313.740 with a p-value of 0.000 tells us that the model as a whole is statistically significant, that is, it fits significantly better than a model with no predictors. All significant coefficients in the model have expected sign and they are in agreement with the actual condition of the study route. However, the level of noise is insignificant. The price variableis highly valued by the respondents and has a significant influence on the bus usage decision. This attribute increases the utility associated with the choice of buses by 0.42169 to private cars. In effect, commuters prefer buses over cars because it is cheaper. The habit attribute which is an obvious reason have a positive sign and increases the utility associated with the choice of a bus by 0.28240. Furthermore, commuters who prefer the habit attribute use bus more frequently than a car. Comfort and departure time (6am-9am; morning trips) have negative sign and decrease the utility as well as the uptake probability of bus choice by 0.37296 and 0.19108 respectively. In other words, when commuters have a mode of choice between using a bus and using a car, these attributes will decrease the utility of their choice of public transport (bus). Commuters who liked the level of comfort in a car usually prefer this mode of transport to a bus. Even though insignificant, the negative sign associated with the level of noise in a bus can be interpreted as; an increase of this attribute will result in disutility of bus choice.

Table 3: Model estimation results

Attributes	Coefficient	Z Value	P>|Z|	[95% Conf. Interval]
Price (yes)	0.42169	10.39	0.000	0.34215 0.50125
Comfort (disagree)	-0.37296	-3.86	0.000	-0.56217-0.18375
Noise (very low/no noise)	-0.04801	-1.04	0.297	-0.13822 0.04219
Time (6am- 9am)	-0.19108	-4.31	0.000	-0.27790-0.10426
Habit (agree)	0.28240	2.93	0.003	0.09339 0.47141
Constant	-0.05880	-0.58	0.561	-0.25702 0.13942
Number of observations	10136			
Prob> χ^2	0.000			
Likelihood χ^2	313.740			
Rho-square	0.022			

Table 4: Marginal effects after logit model

Attributes	dy/dx	Std. Error	Z Value	P>|Z|	[95% Conf. Int.]
Price (yes)	0.10504	0.01004	10.47	0.000	0.085370.12471
Comfort (disagree)	-0.09297	0.02393	-3.89	0.000	-0.13986 -0.04607
Noise (very low/no noise)	-0.01200	0.01150	-1.04	0.297	-0.03455 0.01054
Time (6am- 9am)	-0.04773	0.01105	-4.32	0.000	-0.06939 -0.02608
Habit (agree)	0.07048	0.02399	2.94	0.003	0.11749 0.47307

The result of the marginal effect from Table 4 indicates that for transport mode choice, attributes/levels such as price and habit increase the change in the probability of bus choice by 0.10504 and 0.07048 respectively and are all significant. Comfort and time (6am-9am) attributes are also significant even though they decrease the change in the probability of bus choice by 0.09297 and 0.04773 respectively. The level of noise in a bus is insignificant even though it decreases the change in the probability of bus patronage by 0.01200.

4.0 CONCLUSION

This study sought to assess commuters' attitude on the basis of transport mode choice between using a public transport/bus and using a car when traveling to Accra central or work. The binary logit together with a discrete choice model was employed to estimate the responses of commuters. The effects of certain attributes based on the findings from the study revealed that for transport mode choice; commuters will resort to the use of public transport since the price is relatively cheaper and also, using public transport has been their habit. However, commuters prefer cars to buses as a result of the level of comfort in cars. For morning trips (6am to 9am), commuters prefer cars to buses since they want to get to work/marketplace early. Generally, the level of noise characterized by buses decrease the utility of bus choice.

The direction of this study may be used by transport operators and policy-makers to improve the level of public transport services to attract car users. This will help reduce traffic situation, air and noise pollution, and energy consumptionin urban areas like Accra.

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