

Modeling Mode Choice in Passenger Transport with Discrete Choice Experiment

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ABSTRACT

This article employs a discrete choice experiment technique to assess commuters' attitude when they have an option of choosing a commercial vehicle from Nkrumah-Circle in Accra. This procedure with the binary probit in STATA permits the identification of the choice alternatives defining the experiment by capturing the choices of a user sample. By using the data collected from an experimental survey, a probit model was calibrated and segmented according to trip purposes; commuting and non-commuting trips. The magnitude of estimates generally indicates that commuters highly value travel safety, travel distance comfort, less waiting time, and commercial vehicles with good appearance. However, generally, an increase in transport fare will result in a disutility of commercial vehicle choice.

Keywords: Commercial vehicle, commuters, discrete choice experiment, public transport

1.0 INTRODUCTION

Bus transport in many developing countries started in early 18th century and the companies were controlled by the state. In Ghana, the state transport company was established in 1901 to provide efficient transport services. The other state-owned bus companies established later were City Express Services, Omnibus Services Authority and Metro Mass Company. The informal sector bus transport enterprises also sprang up at the same time and are the larger provider of the country's bus transport needs. Road transport is the predominant means of travelling in Ghana, 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. Transportation has developed rapidly in Ghanaian societies, but there is competition between privately owned cars and commercial vehicles. To him, aside the high growth rate in urban centers like Accra, there have been some shortfalls in public policy. This has contributed to longer shuttling period and journey delays, lengthy waiting times for commercial vehicles both at and between terminals, high accident rates, and localized poor air quality. Further, there is poor terminal organization and management, low standards for traffic awareness, vehicle maintenance, and driver behaviour (Afful, 2011). However, as a result of the poor quality of travel in bus transportation systems in Ghana with a declining trend in commuters' choice of commercial vehicles, policy-makers and transport operators are constantly in search of solutions for improving commercial vehicle choice, especially in urban areas of developing countries. An increase in commercial vehicle 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, Pavlyuk and Gromule (2010) in their study of a preferred transportation mode 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/train choice. Passengers who choose price as a key factor in their selection prefer to use the train. Passengers from 40 to 60 years old use the bus more frequently than the train for regular trips. The terminal point as a destination predictably increases the probability of train selection. Alpizar and Carlsson (2001) examined mode choice between bus and car, with improved bus quality as one of the attributes. Multinomial Logit (MNL) and Random Parameter Logit (RPL) models were employed, the RPL performed better than the MNL. The authors concluded that the best means of attracting passengers is to decrease the bus journey time. Van der Waerden, Borgers, Timmermans, and Berenos (2007) used MNL models 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. Catalano, Lo Casto and Migliore (2008) employed random utility model to analyze travel mode choice behaviour for commuting urban trips in Palermo, Italy. The survey focused on the morning rush hour and involved mainly employees, self employed workers and students whose final destination was located within the historical centre of the city. The authors found out that, 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 limited information on commuters' attitude when they have a mode of choice/option between commercial vehicles that are loading on a bus terminal. In the present study, a Discrete Choice Experiment (DCE) approach which is rooted in Random Utility Theory is used to estimate commuters' attitude towards various attributes of public transport and the variation with trip purposes when they have a mode of choice between commercial vehicles. Trips are categorized as commuting (school, work and business) and non-commuting (recreation and social). This will help to design policy issues that would minimize the use of private cars to reduce traffic/road congestion in urban areas like 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. Both 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 (stated preference survey). The basic shortcomings of SP surveys are not present in RP surveys as they deal with existing actual situations being experienced by the user (Ortúzar and Willumsen, 1994). 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 framework 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 behavior of individuals (Carlsson, Frykblom, and Liljenstolpe, 2003; Hensher, 2001; Hensher and Greene, 2001; Hensher and Sullivan, 2003).

In the present study, discrete choice experiment approach where runs/profiles are generated using various attributes and corresponding levels were presented to the commuters in the form of choice set to observe their preferences. Generally, SP and/or RP data are analyzed using probit models. However, models are determined based on the random part of the utility function. Both the logit family and the probit models are based on a probability distribution. The probit model is based on the Standard Normal distribution and it has an advantage of capturing all the correlations between the alternatives.

2.2 Choice Experiment Design/Survey

In the choice experiment, a number of attributes and assigned levels are used to generate hypothetical scenarios. Binary choice pairs (vehicle1 and vehicle2) 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 runs/profiles taking into account the condition of optimality. These profiles were combined into 28 choice sets, and each surveyed respondent was asked to select the most favorite mode in the choice sets if he/she has an option (mode of choice) between commercial vehicles. Data were collected from 161 Nkrumah-Circle commercial vehicle users in June 2014. Respondents were intercepted while at shopping centers, recreational places, and at offices spread over the area of Nkrumah-Circle in Accra. Earlier studies show that the ideal number of respondents required per design treatment is between 30 and 50 individuals (Hensher, 1994). Normally, 500 to 1000 sample observations are more than adequate to give better estimations (Louviere et al., 2000).

The attributes and corresponding levels employed in this study were decided following discussions with experts and trip makers. According to Adamowvic et al. (1998), attributes are commonly identified from prior experience, primary or secondary research. Table 1 and Table 2 show the attributes/level and choice sets used in the survey.

Table 1: Attributes and corresponding levels

Attributes	Attribute Levels
Appearance of vehicle	Average
	Poor
Safety	Low risk of accidents
	High risk of accidents
Transport fare	Normal fare
	10% more than normal fare
Travel distance comfort	Comfortable seating
	Congested seating
Waiting time at bus stop	Less than 30 minutes
	More than 30 minutes

Table 2: Example of a choice set submitted to commuters

Attribute	Vehicle 1	Vehicle 2
Appearance of vehicle	Average	Poor
Transport fare	Normal fare	10% more than normal fare
Safety	Low risk of accidents	High risk of accidents
Travel distance comfort	Congested seating	Comfortable seating
Waiting time	less than 30 minutes	More than 30 minutes
Which vehicle would you choose?	**Vehicle 1 [ ]**	**Vehicle 2 [ ]**

2.3 Econometric Model

Probit models are essentially econometric models developed on the basis of Random Utility Theory (Thurstone, 1927), where the utility of each element has an observed component denoted by V and a random/disturbance component denoted by ε :

$$U = V + \varepsilon \tag{1}$$

If the deterministic part V is again a function of the observed attributes (x) of the choice as faced by the individual (S) and a vector of parameters (β), then;

$$V = V(x, S, \beta) \tag{2}$$

The probit model was used to estimate the probability of choosing a commercial vehicle given the differences in attributes and corresponding levels from the alternatives. A probabilistic statement made about the model employed for the study based on Maximum Likelihood Estimation technique was therefore presented as;

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$$\Pr\ (Y = 1/X) = \Pr\ (U_{vehicle1} > U_{vehicle2}) \tag{3}$$

$$Y = \beta_o + \beta_1 A_V + \beta_2 A_P + \beta_3 F_N + \beta_4 F_M + \beta_5 T_C + \beta_6 T_D + \beta_7 S_H + \beta_8 S_L + \beta_9 W_L + \beta_{10} W_M + \varepsilon \tag{4}$$

Where: Y = Choice; β_i = Utility coefficient of the attributes; A_V = Appearance of vehicle (average); A_P = Appearance of vehicle (poor); F_N = Transport fare (normal); F_M = Transport fare (10% more than normal fare); T_C = Travel distance comfort (congested seating); T_D = Travel distance comfort (comfortable seating); S_H = Safety (high risk of accidents); S_L = Safety (low risk of accidents); W_L = Waiting time (less than 30 minutes); W_M = Waiting time (more than 30 minutes); ε = error term.

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 400.030 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. The signs of the parameter estimates are as expected and in agreement with the actual condition of the study route. However, transport fare is not significant. The attribute/level safety (low risk of accidents) is highly valued by passengers, and it increases the utility associated with the choice of commercial vehicle by 0.288849 to those without. Also, travel distance comfort (comfortable seating), waiting time (less than 30 minutes), and appearance of vehicle (average) to those without have positive signs and increase the utility as well as the uptake probability of vehicle choice by 0.263338, 0.236152, and 0.096435 respectively. In other words, when commuters have an option to make a choice between commercial vehicles, these attributes will increase the utility of their choice. Even though insignificant, the negative sign associated with transport fare can be interpreted as; an increase of this attribute will result in disutility of vehicle choice.

The parameter estimates from both Table 4 and Table 5 show the segmented model depending on commuting and non-commuting trips. The various attributes estimated in the separate model by commuting trip are generally invariant from the main model in Table 3. The estimates for non-commuting trip in Table 5 increase the utility associated with commercial vehicle choice to those without, and are significant. However, appearance of vehicle (average) is insignificant. Transport fare differs for commuting and non-commuting trips.

4.0 CONCLUSION

This study sought to explore commuters' attitude when they have a mode of choice (option) between commercial vehicles that are loading in a bus station. Discrete choice experiment modeling which is rooted in Random Utility Theory was used to estimate the responses of Nkrumah-Circle bus users. The effects of certain attributes based on the findings from the study revealed that in choosing a commercial vehicle, commuters generally took into consideration their safety, travel distance comfort and waiting time before making their choices. Generally, safety is highly valued by commuters, followed by travel distance comfort, and less waiting time for vehicles at bus stop. Commuters' choice of commercial vehicles generally decreases with an increase of transport fare. A similar observation is reported by Eboli and Mazzulla (2008) for bus users in Cosenza, Italy. However, generally, there is difference in the choice of commercial vehicle by trip purposes (commuting and non-commuting trips). Confirming the observation by Foote et al. (2001) that the quality of each of the public transport attributes is related to the importance each passenger places on it.

The findings of this study may be used by transport operators and policy-makers to formulate strategies for the improvement of public transport to attract private car users in order to resort to the use of public transport; this will help reduce road congestion/traffic situation in urban areas like Accra.

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Table 3: Choice model

Attributes	Coefficient	Z Value	P>|Z|	[95% Conf. Interval]	
Appearance of vehicle (average)	0.096435	3.60	0.000	0.043973	0.148895
Transport fare (10% more than normal fare)	-0.026955	-0.92	0.357	-0.084362	0.030451
Safety (low risk of accidents)	0.288849	9.80	0.000	0.231108	0.346591
Travel distance comfort (comfortable seating)	0.263338	9.79	0.000	0.210635	0.316042
Waiting time (less than 30 minutes)	0.236152	8.00	0.000	0.178263	0.294041
Constant	-0.437358	-14.90	0.000	-0.494872	-0.379844
Number of observations	9012				
Prob> χ^2	0.000				
Likelihood χ^2	400.030				
Rho-square	0.032				

Table 4: Results of the model estimation depending on commuting trips

Attributes	Coefficient	Z Value	P>|Z|	[95% Conf. Interval]	
Appearance of vehicle (average)	0.156732	4.19	0.000	0.083464	0.230000
Transport fare (10% more than normal fare)	-0.172109	-4.08	0.000	-0.254867	-0.089351
Safety (low risk of accidents)	0.276185	6.44	0.000	0.192166	0.360204
Travel distance comfort (comfortable seating)	0.272112	7.12	0.000	0.197178	0.347046
Waiting time (less than 30 minutes)	0.192479	4.48	0.000	0.108304	0.276654
Constant	-0.640444	-14.94	0.000	-0.724458	-0.556431
Number of observations	4739				
Prob> χ^2	0.000				
Likelihood χ^2	225.370				
Rho-square	0.035				

Table 5: Results of the model estimation depending on non-commuting trips

Attributes	Coefficient	Z Value	P>|Z|	[95% Conf. Interval]	
Appearance of vehicle (average)	0.038926	0.99	0.324	-0.038390	0.116241
Transport fare (10% more than normal fare)	0.128291	2.89	0.004	0.041321	0.215262
Safety (low risk of accidents)	0.329854	7.82	0.000	0.247186	0.412522
Travel distance comfort (comfortable seating)	0.223809	5.52	0.000	0.144376	0.303242
Waiting time (less than 30 minutes)	0.280497	6.63	0.000	0.197601	0.363393
Constant	-0.211974	-5.08	0.000	-0.293832	-0.130117
Number of observations	4273				
Prob> χ^2	0.000				
Likelihood χ^2	221.87				
Rho-square	0.039				