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Research Article

A Discrete Choice Modeling of Service Quality Attributes in Public Transport

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Abstract: This study employs a Discrete Choice Experiment (DCE) and Random Utility Theory (RUT) to measure service quality in public transport. 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 based on gender. This model is a way of identifying commuter's attitude on the importance of bus service quality attributes on public transport, which provides an operationally appealing measure of current or potential service effectiveness. The magnitude of estimates generally indicates that commuters highly value bus stop facility, reliability and attitude of driver or mate. However, an increase in the walking distance to the bus stop and transport fare will result in a disutility of service quality attributes.

Keywords: Discrete choice experiment, public transport, service quality, stated preference

INTRODUCTION

Informal commercial bus transport companies have over the years played a major role in the Ghanaian economy. The companies have been created with the aim of achieving profit, but unfortunately, many of these informal companies have suffered major decline in performance, resulting from poor quality of services (Afful, 2011).

Service quality is a subject that has aroused considerable interest both in academic research and in public and private service sectors, where managers are inclined towards customer-focused service and continuous performance improvement. Specifically in public transport, service quality is a matter of the greatest importance because an improvement of quality levels can attract further users. An increase in public transport use, with a concurrent reduction in the use of the private car, could help to reduce many problems like traffic congestion, air and noise pollution and energy consumption (Eboli and Mazzulla, 2008).

For these reasons, several works have been made by various studies on urban public transport; for example, a number of approaches and techniques such as customer loyalty and benchmarks have been used to define, assess and evaluate the level of quality of service. All these methods have been considered at different levels of significance in various countries (Foote *et al*., 2001; Transportation Research Board and Morpace International, 1999).

Many studies have focused on the assessment of public transport level of service (Mfinanga and Ochieng, 2006; Too and Earl, 2010), while others evaluate public transport service quality from the perspective of passenger's satisfaction. For example, Ji and Gao (2010) identified significant factors of satisfaction from the analysis of passenger's satisfaction with public transportation as well as accessibility factors and personal attributes with a Multi-level Logistic regression model. Dell'Olio *et al*. (2010) used Ordered Probit model to evaluate how bus users perceive the quality of their public transport service. Stradling *et al*. (2007) characterized the dimensions of bus service acceptability by examining what bus passengers disliked and liked about travelling by bus in Edinburgh using factor analysis. However, most of the studies are carried out in developed countries with limited information on service quality attributes in developing countries like Ghana.

In the present study, a Discrete Choice Experiment (DCE) modeling approach that provides a service quality measure (i.e., walking distance to bus terminal, attitude of driver and mate, transport fare, bus stop facility and reliability) in public transport from commuter's perspective is adopted. A Probit model for calculating a Service Quality Index (SQI) is estimated.

METHODOLOGY

Approach: To estimate attributes, it is necessary to develop utility models on the basis of user preferences collected in the form of either Stated Preference (SP) or Revealed Preference (RP) data. Although SP and RP data have a wider application, revealed preference surveys are used to observe actual behaviour, rather than

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asking respondents how they would behave in a hypothetical situation (thus stated preference surveys). Travel behaviour as observed in revealed preference survey is then related to various characteristics which influence travel decisions. 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 surveys have two levels, the first level being attitudinal; in which respondents are asked directly how they would respond to various actions or ask them to rank or rate their preferences for various improvements. These surveys are relatively easy to design and implement and have been widely used to estimate the potential impacts of transport system improvements and to determine relative preferences for such improvements. However, attitudinal surveys often significantly over estimate the response to transport system improvement, since passengers tend to be more likely to state that they will change their behaviour than they actually do so. Attitudinal surveys tend to be better suited for evaluating relative preferences and for estimating the maximum possible response to an action, rather than predicting actual shifts in travel demand. The other level being hypothetical choice survey; it requires respondents to make choices between hypothetical alternatives with varying attributes and survey results are then used to develop choice models and to estimate the relative importance of each attribute in common terms. While hypothetical choice surveys overcome many of the limitations of attitudinal surveys, they must be designed carefully and require considerable time and expertise to implement. Both types of preference surveys are limited to the fact that respondents may not have any real-world experience with the choices they are asked to make and may therefore be unable to indicate their preferences with accuracy (U.S. Department of Transport, 1999).

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 (Multinomial Logit model, Nested Logit model, Cross-Nested model and the Generalized Extreme Value model, for example) and the Probit models are based on a probability distribution. The Probit model is based on the Normal distribution and it has an advantage of capturing all the correlations among the alternatives.

Stated choice design: In this study, respondents were asked to choose between pairs of hypothetical bus service quality attributes resulting from the combination of both attributes and corresponding levels. This method requires respondents to trade-off the different aspects of the attributes/levels thereby identifying important attributes in the study. In addition, this process also allows researchers to make sure that each respondent gets an opportunity to evaluate several SP alternatives.

Table 1: Service quality attributes and levels

Attributes	Attribute levels
Walking distance to bus stop	Within 10 min
	More than 10 min
Attitude of driver and mate	Very polite
	Very impolite
Transport fare	Normal fare
	15% more than normal fare
Bus stop facility	Shelter, lighting and seat available
	No shelter, lighting and seat
Reliability	On time late

Survey instrument: Survey instruments are designed for collecting commuter's trip characteristics, socioeconomic characteristics and stated preference /choice from the choice set. A sample survey of University of Ghana students was conducted. The university is situated just 14 km north of the capital city of Ghana (Accra) and has a total student population of 29754 and about 993 senior members of staff (2014).

During week days, a large number of the student body travel by urban bus/commercial vehicles, getting to and from the campus with few using their own private cars. The data were obtained from a stated preference survey conducted in the month of April, 2014 by the researcher. A simple random sampling technique was used to sample 120 students who habitually use commercial vehicles getting to and from the campus. 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.

The service quality attributes/levels employed for this study were decided following discussions with experts and trip makers (students at University of Ghana), which according to Adamowicz *et al*. (1998), attributes are commonly identified from prior experience, primary or secondary research. The attributes and corresponding levels as used in the study are shown in Table 1.

After the attributes and their corresponding levels have been determined, the experiment was designed to elicit the stated choices to be presented to the respondents. A formal statistical design (main effect fractional factorial design) was used before translating into a survey form (questionnaire), taking into account the condition of optimality. Kuhfeld (2010) opined that a design that is optimal is both balanced and orthogonal. Using the orthogonal design facility in SPSS, the full factorial design that consists of (2^5) combination of the attributes and corresponding levels was reduced to eight profiles for the experiment. The eight profiles were combined to generate 28 alternatives to form the choice options in the survey questionnaire. Respondents were asked to compare each of the 28 choice pairs and indicate which bus services they will choose, taking into consideration the attributes/levels. An example of one of the 28 choice sets presented in the stated preference survey, which capture information about trip habits getting to and from the university and, also about public transport service quality presented to the respondents is shown in Table 2.

Econometric model: Probit models are essentially econometric models developed on the basis of RUT (Thurstone, 1927), where the utility of each element has a deterministic component denoted by V and a random 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:

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

The Probit model was used to estimate the probability of choosing bus quality services given the differences in attributes and levels from the alternatives.

The model employed for the study based on RUT was therefore stated as:

$$\Pr ob(Y = 1/X) = \Pr ob(U_{service1} > U_{service2}) \tag{3}$$

$$Y = \beta_o + \beta_1 A_P + \beta_2 A_I + \beta_3 F_N + \beta_4 F_M + \beta_5 W_T + \beta_6 W_M + \beta_7 S_P + \beta_8 S_A + \beta_9 R_O + \beta_{10} R_L + \varepsilon \tag{4}$$

where,

Y = Choice of service quality
β_i = Utility coefficient of the attributes
A_P = Attitude of driver and mate (very polite)
A_I = Attitude of driver and mate (very impolite)
F_N = Transport fare (normal)
F_M = Transport fare (15% more than normal fare)
W_T = Walking distance to bus stop (within 10 min)
W_M = Walking distance to bus stop (more than 10 min)
S_P = Bus stop facility (shelter, lighting and seat present)
S_A = Bus stop facility (no shelter, lighting and seat)
R_O = Reliability (on time)
R_L = Reliability (late)
ε = Error term

Variables used for the discrete choice experiment question were manually generated using binarycodes 0 and 1.

RESULTS AND DISCUSSION

The result reported in Table 2 reveals that there is goodness-of-fit of the model from the data. The likelihood ratio chi-square of 358.310 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, walking distance to the bus stop and transport fare are not significant. Bus stop facility (i.e., availability of shelter, lighting and seat) is highly value by passengers and it increases the utility associated with the choice of bus service attributes to those without by 0.454968. Also, attribute/level such as reliability (on time) to those without and attitude of driver or mate (very polite) to attitude of driver or mate (very impolite) have positive signs and increase the utility as well as the uptake probability of bus service quality attributes by 0.355541 and 0.100080, respectively. In other words, these attributes will increase the utility associated with the choice of bus service quality attributes in public transport (Table 3).

The parameter estimates from both Table 4 and 5, portray the segmented model depending on gender. All the attributes estimated in the segmented model by male commuters are in line with the estimates and arguments raised about the main model in Table 3. The estimates in the segmented model by female commuters in Table 5 have the expected sign and are significant at the

Table 2: Example of a choice set submitted to respondents

Attribute	Service 1	Service 2
Walking distance to bus terminal	Within 10 min	More than 10 min
Attitude of driver and mate	Very polite	Very impolite
Transport fare	15% more than normal fare	Normal fare
Bus stop facility	Shelter, light and seat present	No shelter, light and seat
Reliability	On time	Late
Which service would you choose?	Service 1 [ ]	Service 2 [ ]

Table 3: Results of the model estimation

Attributes	Coefficient	Z-value	P>|Z|	(95% Conf. Interval)	
Attitude of driver/mate (very polite)	0.100080	3.22	0.001	0.039147	0.161014
Transport fare (15% more than normal fare)	-0.062461	-1.76	0.079	-0.132170	0.007247
Walking distance to bus stop (Within 10 min)	-0.055601	-1.79	0.074	-0.116534	0.005331
Bus stop facility (shelter/lighting/seat present)	0.454968	14.63	0.000	0.394035	0.515901
Reliability (on time)	0.355541	11.44	0.000	0.294607	0.416474
Constant	-0.412692	-11.35	0.000	-0.483944	-0.341440
Number of observations	6716				
Prob> χ^2	0.000				
Likelihood χ^2	358.310				
Rho-square	0.038				

Table 4: Results of the model estimation depending on male commuters

Attributes	Coefficient	Z-value	P>|Z|	(95% Conf. Interval)	
Attitude of driver/mate (very polite)	0.156738	3.66	0.000	0.072868	0.240608
Transport fare (15% more than normal fare)	-0.027127	-0.55	0.580	-0.123133	0.068878
Walking distance to bus stop (Within 10 min)	-0.012291	-0.29	0.774	-0.096161	0.071579
Bus stop facility (shelter/lighting/seat present)	0.390590	9.13	0.000	0.306719	0.474460
Reliability (on time)	0.349360	8.16	0.000	0.265490	0.433230
Constant	-0.435031	-8.65	0.000	-0.533608	-0.336455
Number of observations	3528				
Prob>χ^2	0.000				
Likelihood χ^2	162.42				
Rho-square	0.033				

Table 5: Results of the model estimation depending on female commuters

Attributes	Coefficient	Z-value	P>|Z|	(95% Conf. Interval)	
Attitude of driver/mate (very polite)	0.035499	0.78	0.433	-0.053326	0.124326
Transport fare (15% more than normal fare)	-0.101870	-1.97	0.049	-0.123133	0.068878
Walking distance to bus stop (Within 10 min)	-0.107255	-2.37	0.018	-0.196079	-0.018430
Bus stop facility (shelter/lighting/seat present)	0.529142	11.68	0.000	0.440318	0.617967
Reliability (on time)	0.365470	8.06	0.000	0.276644	0.454295
Constant	-0.388617	-7.38	0.000	-0.491791	-0.285442
Number of observations	3188				
Prob>χ^2	0.000				
Likelihood χ^2	207.840				
Rho-square	0.047				

95% confidence level. However, attitude of driver/mate (very polite) is not significant.

The negative sign associated with walking distance to the bus stop (within 10 minutes) and transport fare (15% more than normal fare) indicate that as these factors increase, they decrease the utility of bus service attributes choice.

Also, bus stop facility (i.e., availability of shelter/lighting/seat), reliability (on time) and attitude of driver or mate (very polite) increase the utility of bus service quality attributes choice by female commuters, to those without and they are in line with attributes estimated in the main model. Generally, there is difference in bus service quality attributes choice by gender.

CONCLUSION

The main purpose of this study was to explore commuters attitude towards the choice of bus service quality attributes in public transport. Discrete choice modeling and Random Utility Theory were used to capture the responses of students in University of Ghana who habitually use urban bus/commercial vehicles getting to and from the university campus.

The utility of each alternative represents an SQI of each bus package and the values of parameters are the attribute weights. This is a way for quantifying the improvement of service quality as a consequence of an improvement of the service quality attributes.

SQI is useful to planners and transit operators for measuring the importance of service quality attributes. The effects of certain attributes based on the findings from the study revealed that in choosing bus service quality attributes, commuters took into consideration; bus stop facility, reliability and attitude of driver or mate before making their choices. Generally, bus stop facility is highly valued by commuters, followed by reliability and attitude of driver or mate. However, commuter's choice of bus service quality attributes (utility) decrease with an increase in the walking distance to the bus stop and transport fare. This supports the findings of Eboli and Mazzulla (2008) that an increase of fare and distance from the bus stop involves a decrease of utility. However, there is difference in the choice of bus service quality attributes by gender. Confirming the observation by Dell'Olio *et al*. (2010) and Foote *et al*. (2001) that the quality of each of the public transport service attributes is related to the importance each passenger places on it. Though contextual, the findings of this study may be used by planners and policy-makers to formulate strategies for improvement of urban bus service attributes.

The estimated results might not seem very useful for measuring the service quality of public transport in an urban area, because it relates to a specific category of users (University students). However, they are a relevant part of total public transport users.

Further developments of this study may be identified by considering a range of bus service quality attributes (SQI) and employ more complex Logit models, like Hierarchical-Logit or Mixed Logit models.

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