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 transport as well as accessibility factors and personal attributes with a Multi-level Logit 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
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.

| 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 (2^3) 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 \( \varepsilon \):

\[
U = V + \varepsilon
\]

(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 \((\beta)\), then:

\[
V = V(x, S, \beta)
\]

(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:

\[
\Pr(\text{ob}(Y = 1|X) = \Pr(\text{ob}(U_{\text{serve1}}) > U_{\text{serve2}}))
\]

(3)

\[
Y = \beta_0 + \beta_1 A_P + \beta_2 A_I + \beta_3 F_N + \beta_4 F_M + \beta_5 W_T + \beta_6 W_M + \beta_7 S_P + \beta_8 R_o + \beta_9 R_l + \varepsilon
\]

(4)

where,

- \( Y \): Choice of service quality
- \( \beta_i \): 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)

Variables used for the discrete choice experiment question were manually generated using binary codes 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
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REFERENCES

Adamowicz, W., J. Louviere and J. Swait, 1998. Introduction to attribute-based stated choice methods. Final Report to Resource Valuation Branch Damage Assessment Center, NOAA, U.S. Department of Commerce, Washinton, U.S.A.

Afful, D., 2011. The challenges confronting private bus operators in Ghana. Unpublished M.B.A. Thesis, Maastricht School of Management, Maastricht, Netherlands.

Dell'Olio, L., A. Ibeas and P. Cecin, 2010. Modelling user perception of bus transit quality. Transport Policy, 17: 388-397.

Eboli, L. and G. Mazzulla, 2008. A stated preference experiment for measuring service quality in public transport. Transport. Plan. Techn., 31(5): 509-523.

Foote, J., G. Stuart and R. Elmore-Yalch, 2001. Exploring customer loyalty as a transit performance measure. Transp. Res. Record, 1753: 93-101.

Hensher, D.A., J.M. Rose and W.H. Greene, 2005. Applied Choice Analysis: A Primer. Cambridge University Press, Cambridge.

Ji, J. and X. Gao, 2010. Analysis of people's satisfaction with public transportation in Beijing. Habitat Int., 34: 464-470.

Kuhfeld, W.F., 2010. Construction of efficient designs for discrete choice experiment. J. Market Res., 31: 375-383.

Mfinanga, D. and M. Ochieng, 2006. Development of a model for assessing urban public transport level of service in cities of developing nations. Afr. J. Sci. Technol., 7: 35-53.

Ortúzar, J.D. and L.G. Willumsen, 1994. Modelling Transport. 2nd Edn., John Wiley and Sons, United Kingdom.

Stradling, S., M. Carreno, T. Rye and A. Noble, 2007. Passenger perceptions and the ideal urban bus journey experience. Transport Policy, 14(4): 283-292.

Thurstone, L.L., 1927. A law of comparative judgment. Psychol. Rev., 4: 273-286.

Too, L. and G. Earl, 2010. Public transport service quality and sustainable development: A community stakeholder perspective. Sustain. Dev., 18: 51-61.

Transportation Research Board and Morpace International, 1999. A Handbook for Measuring Customer Satisfaction and Service Quality. Transportation Research Board, Washington, D.C.

U.S. Department of Transport, 1999. Guide Book on Methods to Estimate Non-motorized Travel: Supporting Documentation. Federal Highway Administration-research, Consultancy and Technology, Georgetown Pike, Mclean, United States.