ANALYSING BUS PASSENGERS' SATISFACTION IN DHAKA USING DISCRETE CHOICE MODELS

Mohammed Quddus*
Professor of Intelligent Transport Systems
Transport Studies Group
School of Architecture, Building and Civil Engineering
Loughborough University
Loughborough LE11 3TU
United Kingdom
email: m.a.quddus@lboro.ac.uk

Farzana Rahman
Professor
Department of Civil Engineering
University of Asia Pacific
Green Road, Dhaka - 1205
Bangladesh
email: farzana-ce@uap-bd.edu

Fredrik Monsuur
PhD Candidate
Transport Studies Group
School of Architecture, Building and Civil Engineering
Loughborough University
Loughborough LE11 3TU
United Kingdom
Email: F.Monsuur@lboro.ac.uk

Juan de Ona
Professor
Department of Civil Engineering
University of Granada
18071 Granada
Spain
Email: jdona@ugr.es

Marcus Enoch
Professor of Transport Strategy
Transport Studies Group
School of Architecture, Building and Civil Engineering
Loughborough University
Loughborough LE11 3TU
United Kingdom
email: m.p.enoch@lboro.ac.uk

***Corresponding author**

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ABSTRACT

The bus transport system in Dhaka is unsafe, unreliable and inefficient, and struggles to cope with the day-to-day mobility of its massive population. Consequently, measuring the performance of bus service quality (SQ) from the customers' perspective is fundamental in planning a sustainable bus transport system for Dhaka, and in developing the associated policies and regulations. Although there are some studies addressing the performance of the public transport systems in Bangladesh, little research considers how SQ attributes affect passengers' satisfaction. The purpose of this paper is to examine a relationship between bus SQ and its influencing factors in Dhaka. Using a customer satisfaction survey with a sample size of 955, discrete choice models (e.g. multinomial logit and mixed logit) have been developed. The results indicate that the inhabitants, as expected, are dissatisfied with their bus services (less than 10% rated SQ as either excellent/good) and service attributes such as comfort level and driver skills were found to be the most important contributors towards the poor and very poor perceptions of SQ. Other influencing factors are punctuality, safety, entry and exit processes, waiting time and vehicle condition. One surprising finding was that the multinomial logit model provides better goodness-of-fit for the sample data relative to the mixed logit model implying that bus users in Dhaka may represent a homogeneous group as they do have access to other modes. Findings from this study can be utilised to develop policies and regulations to improve bus transport in Dhaka.

***Keywords*:** Bus service quality, Passenger satisfaction, Developing megacity, Multinomial logit, Mixed logit

INTRODUCTION

Dhaka, the capital of Bangladesh and a developing megacity in South Asia, is one of the most densely populated and highly congested cities in the world with a population density of 122,700 per square mile in 2018 (*1*). This is for two reasons. First, because since its birth as a provincial city in 1608, Dhaka has grown mostly without proper planning strategies, and hence is substantially organic in its structure. Second, Dhaka has witnessed one of the fastest growth rates (i.e. 4.2 percent annually) among megacities world-wide. Thus, the population has grown from around half a million in 1965 to 18 million in 2016. Moreover, the city is set to be home to more than 20 million people by 2025, therefore becoming the world's fifth most populous city (2). In addition, being the economic and political capital of Bangladesh puts further pressure on space and on resources for developing new transport infrastructure, whilst almost half of Dhaka's population is classed as being 'poor' (3).

In transport terms, what is needed is an efficient and affordable transport system so that the city is able to function effectively, but in reality, these factors have all combined such that the city is in 'crisis' (4). Specifically, the issues are as follows. (1) Significant traffic congestion in every part of the road network leading to highly unpredictable travel times. This is despite the country having one of the lowest rates of motorisation in the world, whereby private car ownership is only 0.3% in 2012 according to the World Bank; (2) Unsafe, unreliable and inefficient public transport systems whereby inadequate transport facilities for the day-to-day mobility of Dhaka's massive population are negatively affecting the availability, quality and integrity of its public transport services, particularly through severe delays and unreliability, and hence public transport users unsurprisingly become very disappointed and dissatisfied with the quality of service (5, 6). (3) Heterogeneous mixed traffic sharing the same roadway with a high proportion of non-motorised transport. (4) Very risky user behaviour leading to safety issues and high level of pedestrian fatalities. (5) An obvious disparity between transport demand and supply where demand is significantly suppressed by a lack of supply.

For the future, these circumstances point to a future where the bus, as the main mode of public transport, is the only feasible alternative to alleviate the public transport 'crisis' in Dhaka, and measuring the performance of bus service from the passengers' perspective is a key part of this effort.

Factors affecting the performance of bus service quality have recently received significant attention across the world. While the performance evaluation of bus transport has been fundamental to operators, there is an increasing emphasis on the better understanding of service quality attributes with respect to the needs of the customers (e.g.7). This is because a strong connection has been established between service quality and customer satisfaction (e.g. 8, 9) and service providers are willing to better understand the factors affecting customers' satisfaction so as to enhance their profitability. Therefore, most of these factors in the literature have been identified through customer satisfaction surveys and can be grouped as: socio-economic conditions of the passengers, trip characteristics, lane-use patterns, service characteristics, network coverage, vehicle characteristics, and accessibility.

However, the context of developing countries is very different from situations elsewhere: factors influencing user satisfaction change from region to region. For example, Diana (10) concludes that the inhabitants of large agglomerations are less satisfied with their public transport services than those living in less densely populated areas. Other geographical and cultural factors too, as well as differences between public transport services and infrastructure, will have an influence on the overall satisfaction that users have of the service provided (11).

Although there are studies focusing on the performance of the overall public transport systems in Bangladesh (e.g. 12), there is a dearth of research on the factors influencing the service quality of bus transport in Dhaka. The aim of this paper is therefore to develop a statistical association between bus service quality and its influencing attributes. Data from a customers' satisfaction survey consisting of 955 respondents from Dhaka are used in the analysis using discrete choice models.

The paper is organised as follows: section 2 reviews existing literature, section 3 provides details on data collection and descriptive statistics, section 4 sets out the statistical techniques employed in the analysis, section 5 presents the results, section 6 notes policy implications and gives a discussion, and section 7 draws out some conclusions.

LITERATURE REVIEW

Brief Context of Dhaka's Transport

Dhaka is the only city of its size (142 square mile) in the world not to have either an organised bus transport system (e.g. bus rapid transit) or a mass rapid transit. Figure 1 shows the composition of the vehicle fleet in Dhaka according to Bangladesh Road Transport Authority (BRTA). Although vehicle categories are largely dominated by passenger cars and motorcycles (i.e. 89% of the total fleet), the bus modal share in Dhaka is 38% (14). Despite this, Dhaka has a disproportionate amount of buses relative to its residents who want to use them. For instance, there are 7,600 buses for 4.6 million people in Sri Lanka whereas Dhaka has a total of 2,000 buses for 10 million inhabitants (15). Readers are referred to Katz and Rahman (16) for more information on the bus transport in Dhaka. In order to alleviate chronic traffic congestion, poor air quality and the misery of public transport users in Dhaka, the government of Bangladesh started to build two Bus Rapid Transit (BRT) routes in 2013 with a total length of 76 km and a metro rail system (started in 2016) with a length of 20km and both are expected to be operational by 2019 and will carry 85,000 passengers (metro rail: 60,000 and BRT: 25,000) per hour according to Dhaka Mass Transit Company Ltd. The BRT system is expected to significantly increase the bus modal share in Dhaka from 38% to 69% (6).

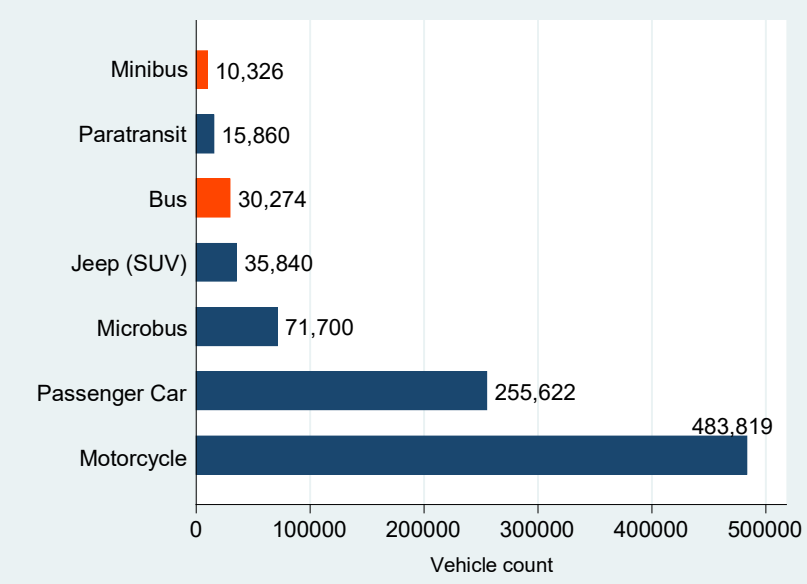

Figure 1: Vehicle composition in Dhaka (source: BTRA)

Service Quality: Developed vs Developing Nations

Transit service quality has emerged in recent years as a popular topic among researchers, not only in developed countries (17), but also in developing ones, whereby studies in this field have begun to emerge since the beginning of this decade (e.g. 18, 19, 20, 21, 22, 23, 24, 25, 26).

However, differences still exist between the methodologies used to analyse service quality in both contexts. Typically, more sophisticated models are used in developed countries, predominantly discrete choice models (e.g. 27, 28, 29), structural equation models (e.g. 30, 31, 32, 33), and data mining algorithms (e.g. 34, 35). Many cases also use advanced sample stratification techniques, such as cluster analysis, to reduce the heterogeneity in users' perception (e.g. 29, 36) or more complex models with random parameters that also consider such heterogeneity (e.g. 37). In addition, variants of these techniques are often combined to address the same analysis to determine more precise and personalised information which allows the service operator to carry out more individual marketing campaigns or take specific measures focusing to particular user profiles (29, 36, 38, 39).

By contrast in developing countries, simpler analysis tools are normally employed based on the SERVQUAL model for instance (e.g. 19, 20, 21, 22, 24), factor and/or regression analysis (e.g. 18, 25), or simple structural equation models (e.g. 22, 40). For example, Irfan et al. (22) investigated passenger perceptions of quality of a railway system in Pakistan by employing a modified

SERVQUAL model. The proposed model considered eight dimensions and by using a structural equation model, determined the relationship between these service quality attributes and passenger satisfactionSimilarly, Mahmoudi et al. (19) investigated customer satisfaction for the bus rapid transit in Tehran (Iran) based on the SERVQUAL scale but used a Pearson correlation. Likewise, on the basis of SERVQUAL and rail transport quality, Prasad and Shekhar (20) developed the RAILQUAL instrument for analysing passenger satisfaction on Indian railways. They added three new dimensions (comfort, security and convenience) to the five original SERVQUAL scales. Ojo et al. (24) used the SERVQUAL methodology to evaluate the perspective of the passengers of an intercity bus service on the route between Cape Coast and Accra in Ghana. The Istanbul high-speed train was researched by Alpu (25) using a factorial analysis and a regression model to determine the relevant factors affecting passengers' overall satisfaction towards the service.

However, the SERVQUAL model does have some disadvantages when compared to other methodologies (41). One is that the SERVQUAL model collects data on passenger expectations and perceptions at the same time, and this can be confusing for the passengers being interviewed. Moreover, SERVQUAL information can only be collected by using long interviews and this has a negative effect on response ratios and the overall precision of the survey, and consequently this methodology is now being used much less in countries with more experience of analysing public transport service quality (e.g. in the USA and Europe), although transit operators still use it.

An alternative analytical approach would be to apply discrete choice models such as multinomial logit models and their extensions such as latent class models and mixed logit models. There is a significant advantage of employing a discrete choice model. For instance, mixed logit models could consider the perceptions of individual users for bus service quality, which is important in controlling for unobserved heterogeneity, and these models have been used in developed countries (e.g. 37, 42).

Factors Affecting Service Quality

The most important factors affecting customer satisfaction also depend on the geo-social context and the service analysed (bus, railways or airlines). Nevertheless, in the case of public bus services, some aspects of the service can be seen to be particularly important for almost all the studies (41), irrespective of the urban context analysed. These variables are frequency, travel time (also known as speed in some studies), safety, reliability and punctuality. It is worth highlighting that very few studies have been carried out on public transport bus services in medium to low income areas, where most passenger satisfaction studies have been performed on railway services (e.g. 17). In most of these studies, safety appears to be a key factor on customer satisfaction. In any case, the variables exerting the most influence on the users of public transport, representing the needs and requirements of the users of the service, cannot be generically extrapolated from one service to another, as they are specific to each transport system (41). They also depend on a large number of factors, such as the geographical context, the type and mode of public transport, and the culture and tradition of the users, among others.

It is clear from the review of current literature that service quality from a customer point of view is fundamental to bus transport management and operations. More specifically, service providers and operators are required to better understand service quality attributes to formulate policies and strategies that can enhance customers' satisfaction. It is also revealed that context-specific attributes are important for the evaluation of service quality. Currently, whilst there have been several rail-based service quality studies in developing countries, there have only been very few studies on bus service quality. Also, none of the studies in developing countries have used discrete choice models for identifying the most important factors affecting customer satisfaction as far as the authors are aware.

This study therefore aims to fill this gap in knowledge by using discrete choice models to analyse customer data from bus users in Dhaka to examine the relationship between overall bus service quality and influencing factors.

DATA COLLECTION

The quality of bus service data was gathered through a face-to-face survey amongst bus passengers at 15 major bus stands along the bus routes in Dhaka. The survey was carried out between 9:00 am and 5:00 pm during the morning and evening peak periods in March 2017 by 8 skilled enumerators. The survey was primarily conducted during weekdays except only one day during the weekend. Convenience sampling technique was adopted. The questionnaire had a total 40 questions covering seven parts: trip characteristics, quality of service, quality of bus, safety and security of bus, quality of bus stop, courtesy of helpers/conductors and reliability and accessibility of bus. The passengers were asked to rate their perception on these service components on a five-point Likert scale ranging from 1 to 5 (where 1 means 'very poor' and 5 means 'excellent'). In total, 955 respondents completed the survey, providing their opinions on a range of service attributes that describe the quality of bus service with respect to their satisfaction, as well as their personal characteristics. About 87% of the survey respondents stated that bus transport is their main mode of travel and more than 50% of the respondents are quite young (i.e. 20-30 years of old). The original dataset coded all variables in five categories, ranging from 'excellent' to 'very poor'. From the descriptive statistics of the surveyed variables, it was apparent that the 'excellent' category is very rare – less than 1% of the observations indicating that a miniscule proportion of respondents was chosen this category across the variables. For analysis purposes, both 'excellent' and 'good' categories were therefore combined into a single category and termed as the quality of bus service to be 'good'.

Table 1 displays the variables that were considered for the analysis. The satisfaction variables are coded into dummy variables (i.e. satisfied = 1 when service quality perceives as 'excellent', 'good' or 'satisfactory' and dissatisfied =0 when service quality perceives as 'poor' or 'very poor'), indicating that the respondent is satisfied with that service attribute. This table displays the number of satisfied respondents per satisfaction outcome, as well as the share of satisfied respondents per satisfaction outcome. For instance, 79 respondents were satisfied with the 'accessibility of the vehicle' when they rate the overall service quality as 'excellent/good', whist there are 94 responses in that category. Therefore, the share of satisfied respondents with that service attribute is 79/94 = 84%. Finally, the total share of satisfied respondents is displayed. Most of the service and personal characteristic variables are coded as dummy variables as well.

With regards to the satisfaction indicators, it is quite striking that very few passengers have rated the service aspects as 'Satisfactory', 'Good' or 'Excellent'. Only accessibility has a share with more than 50% of satisfied respondents. Passengers are not likely to be satisfied with aspects that describe the vehicle (ease of entry and exit, vehicle condition, noise level, comfort level) which indicates that investment is needed in the vehicle fleet. Passengers do not seem satisfied with the driving skills and punctuality of the service either. With regards to the dependent variable, overall bus quality, most passengers rate the service as 'Poor' or 'Very poor'.

Respondents were also asked to give information on their personal characteristics. The majority of respondents in the sample is male (about 70%). This is important to keep in mind, as it is demonstrated in other settings that females are more likely to rate public transport services as satisfactory, whilst there may also be implications for results related to personal safety.

Table 1: Descriptive statistics of customers' satisfaction survey data

	Excellent or Good	Satisfactory	Poor	Very poor	Satisfied users
Dependent variable:					
Bus service quality	94	251	390	220	36%
Satisfaction indicators:					
Accessibility of the vehicle	79 (84%)	181 (72%)	152 (39%)	69 (31%)	50%
Vehicle condition	77 (82%)	155 (62%)	61 (16%)	33 (15%)	34%
Comfort level	88 (94%)	170 (68%)	56 (14%)	28 (13%)	36%
Convenience of service	74 (79%)	178 (71%)	125 (32%)	55 (25%)	45%
Condition of bus	85 (90%)	168 (67%)	64(16%)	33 (15%)	37%
Cost of travel	66 (70%)	152 (61%)	187 (48%)	95 (43%)	52%
Driver skills	77 (82%)	167 (67%)	120 (31%)	51 (23%)	43%
Ease of entry and exit	81 (86%)	159 (63%)	71 (18%)	39 (18%)	37%
Frequency of service	78 (83%)	187 (75%)	180 (46%)	77 (35%)	55%
Noise level of the vehicle	74 (91%)	164 (65%)	81 (21%)	39 (18%)	37%
Paying fare/ticketing system	70 (74%)	138 (55%)	116 (30%)	54 (25%)	40%
Punctuality	77 (82%)	152 (61%)	108 (28%)	37 (17%)	39%
Reliability of service	50 (53%)	74 (29%)	48 (12%)	18 (8%)	20%
Seat condition	75 (80%)	159 (63%)	79 (20%)	42 (19%)	37%
Personal characteristics:					Share
Gender (male)	60 (64%)	170 (68%)	282 (72%)	129 (59%)	67%
Reason for using bus: no own transport	28 (30%)	106 (42%)	106 (27%)	58 (26%)	31%
Trip purpose: Work	44 (47%)	145 (58%)	205 (53%)	76 (35%)	49%
Trip purpose: School	26 (28%)	63 (25%)	116 (30%)	89 (40%)	31%
Trip purpose: Other	24 (26%)	43 (17%)	69 (18%)	55 (25%)	20%
Age (year)	Mean: 30		Std. Dev.: 9		
Income (1,000 Tk., monthly)	Mean:22		Std. Dev.: 15		
Service characteristics:					Share
Level of personal safety from crime	55 (59%)	62 (25%)	30 (8%)	21 (10%)	18%
Bus service is always crowded	54 (57%)	149 (59%)	313 (80%)	193 (88%)	74%
Travel more than twice a week	73 (78%)	199 (79%)	292 (75%)	168 (76%)	77%
Time to reach bus stop (minutes)	Mean:12.9		Std. Dev.: 6.0		
Waiting time (minutes)	Mean: 16		Std. Dev.: 5.8		

With regards to the reasons for using public transport, it is noteworthy to see that 30% state that they use the bus because of the low cost, while another 54% state that they use the bus because they have no alternative transport. Only a small part of the sample states that they use the bus because of the speed or safety benefits. It seems then that bus users are 'captives' for which alternative means of transport might be out of reach. The frequency of travel indicates this too, as 77% travel by bus more than twice a week. With regards to trip purpose, most of the passengers use the bus to go to work or to attend school, whilst other respondents stated trip purposes such as leisure, museum visit, family visit etc. The average time to reach the bus stop is 13 minutes whereas the average waiting time is 16 minutes. The waiting time seems long, perhaps indicating that buses have difficulties in

penetrating through the congested traffic or that passengers have trouble boarding the first available bus due to overcrowded services.

Finally, respondents were asked to give a statement about the service characteristics of the bus with regards to safety and crowdedness. A striking finding is that very few respondents regard the bus service as safe with respect to crime, which in many developed countries is an important driver of passenger satisfaction. Most of the respondents also stated that the bus is usually very crowded.

Taking the quality of bus service as a discrete random variable and coded it as an ordinal scale with good=4, satisfactory=3, poor=2, and very poor=1, the expected value of the bus quality can be obtained through a discrete probability density function where:

$$Mean = \mu = \sum_{i=1}^{N} x_i.p(x_i) \quad and \ Variance = \sum_{i=1}^{N} {x_i}^2.p(x_i) - \mu^2$$

where x is the discrete random variable (i.e. quality of bus service) with possible values x_1, x_2, x_3 and x_4; the corresponding probabilities are $p(x_1)$, $p(x_2)$, $p(x_3)$ and $p(x_4)$.

Quality of bus service (i.e. x)	Count	P(x)	x.p(x)	x^2.p(x)
1= Very Poor	220	0.230	0.230	0.230
2= Poor	390	0.408	0.817	1.634
3= Satisfactory	251	0.263	0.788	2.365
4= Good/Excellent	94	0.098	0.394	1.575
Total	**955**	**1.000**	**2.229**	**5.804**

Expected value of the quality of bus service = 2.223 with a standard deviation of 1.89

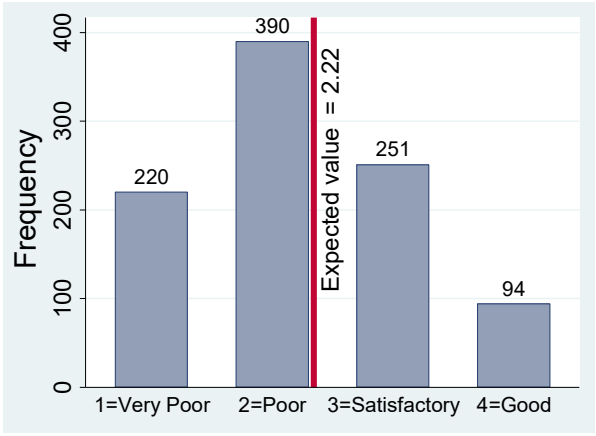

Figure 2: Expected value and standard deviation of the user satisfaction on the quality of bus service

If we were to randomly select a bus user in Dhaka, the expected score would be 2.22 on a scale of 1 to 4 where 1 means the quality of the service is very poor and 4 means the quality of the service is good/excellent (see Figure 2). This indicates that the overall service quality is poor in Dhaka. The following modelling exercise will reveal some of the important factors that affect the quality of bus service.

DISCRETE CHOICE MODELS

As discussed, the bus quality satisfaction data is coded on a four point Likert scale from the highest level to the lowest level (i.e. 4='Good', 3= 'Satisfactory', 2= 'Poor', 1= 'Very poor'). Taking the data structure into account, a multinomial logit model of satisfaction outcomes, the propensity of respondent *i* towards satisfaction outcome *k* can be represented by severity propensity function U_{ki}:

$$U_{ki} = \propto_k + \beta_k X_{ki} + \varepsilon_{ki}$$

where $\propto_k$ is a constant parameter for satisfactioncategory *k*; $\beta_k$is a vector of the estimable parameters for satisfaction category k; *k=1,.....,K* (*K*=4 in this case), representing all the satisfaction levels; X_{ki} represents a vector of the explanatory variables affecting the satisfaction level for *i* at severity category *k*. ε_{ki} is a random error term. Equation 2 shows how to calculate the probability for each satisfaction category. Let $P_i(k)$ be the probabilty of respondent *i* ending in satisfaction outcome *k*, such that (43):

$$P_i(k) = \frac{\exp(\propto_k + \beta_k X_{ki})}{\sum_{vk} \exp(\propto_k + \beta_k X_{ki})}$$

The multinomial logit formula is derived under the assumptions of independently and identically distributed (iid) extreme value, which is potentially a restrictive assumption. It is unlikely that representative utility V_{ik} is precise enough to approach random utility U_{ik} as there is the potential for random taste variation. In order to capture random taste variation, the multinomial logit model can be extended to a mixed logit model. Mixed logit probabilities are the integrals of the standard logit probabilities over a density of parameters. In other words, it is the weighted average of the logit formula, evaluated at different parameters β with the weights given by density $f(\beta)$. The mixed logit model shares the same structure of the severity propensity function U_{ki} as it is an extension of the multinomial logit model (43):

$$P_i(k) = \frac{\exp(\propto_k + \beta_k X_{ki})}{\sum_{\forall k} \exp(\propto_k + \beta_k X_{ki})} f((\beta|\theta) d\beta$$

Where $f(\beta|\theta)$ is the density function of β with θ referring to a vector of parameters of the density function, which typically contains mean and variance (with normal distribution). The mixed logit specification can be compared with multinomial logit specification using the likelihood ratio test, as the mixed logit formula can 'collapse' back into multinomial logit.

RESULTS

Both multinomial logit and mixed logit models were developed with the customers' satisfaction survey data. All variables in the survey data were considered with only the statistically significant ones being retained in the final models in order to achieve a parsimonious model. The estimates of the proposed choice model are presented in Table 2. All explanatory variables appearing in Table 2 are statistically significant at the 5% significance level. While estimating a multinomial logit model, one satisfaction alternative is normalized to have a coefficient equal to zero. The interpretation of the parameters corresponding to other alternatives is therefore relative to the normalised category. The choice of a reference category can make a difference since effects are interpreted for each alternative vis-a-vis the reference category. In this case, the reference category - the 'satisfactory' category was utilised to contrast the findings with the 'Excellent/Good' and 'Poor' and 'Very poor' categories. The parameter β gives the change in the log odds, when X_{ki} changes by one unit.

Goodness of fit statistics and the most parsimonious model

The adjusted R-squared (pseudo) for the multinomial logit model has a value of 0.24, which is a good fit for satisfaction data. A mixed logit model was also estimated, using 1000 Halton draws and normal distributions for random parameters. However, the log-likelihood of the mixed logit model is not significantly better relative to the multinomial logit model. The multinomial logit model is, therefore, superior and more parsimonious.

Table 2: Modelling results

	MNL			RPL		
Bus service quality: satisfaction levels	**Excellent/ Good**	**Poor**	**Very Poor**	**Excellent/ Good**	**Poor**	**Very Poor**
Alternative specific constant	-2.87 (-6.17)	3.19 (10.63)	1.83 (5.9)	-2.87 (-6.12)	3.38 (9.85)	2.03 (5.68)
Satisfaction indicators:						
Ease of entry and exit		-0.65 (-3.23)			-0.83 (-3.23)	
Accessibility of the vehicle		-0.53 (-2.5)	-0.78 (-3.32)		-0.6 (-2.46)	-1.26 (-2.74)
Noise level of the vehicle		-0.78 (-3.62)	-0.87 (-3.39)		-0.88 (-3.45)	-0.98 (-3.34)
Vehicle condition		-0.86 (-3.73)	-0.77 (-2.82)		-0.96 (-3.56)	-0.87 (-2.71)
Punctuality	0.66 (2.08)			0.65 (2.06)		
Comfort level	1.47 (3.12)	-1.34 (-5.6)	-1.45 (-5.04)	1.48 (3.2)	-1.57 (-4.98)	-1.63 (-4.79)
Driver skills		-0.76 (-3.67)	-1.1 (-4.63)		-0.82 (-3.46)	-1.21 (-4.49)
Personal characteristics:						
Reason of using bus: Work	-0.67 (-2.57)		-0.74 (-4.36)	-0.69 (-2.63)		-0.84 (-4.43)
Service characteristics:						
Level of personal safety from crimes	1.32 (5.07)			1.32 (5.04)		
Bus service is always crowded			0.54 (2.22)			0.58 (2.14)
Waiting time		-0.044 (-3.42)			-0.042 (-3.02)	
Random parameters std. dev:						
Accessibility of the vehicle					1.33 (2.37)	1.43 (1.97)
Model statistics:						
Log Likelihood (β)		-916.94			-915.12	
Adjusted (pseudo) R^2		0.2458			0.2473	
AIC		1875.9			1876.3	
Sample size		955			955	

Z statistics in parentheses

Satisfaction variables

Several satisfaction indicators have been included in the model. With regards to the *ease of entry and exit*, the model suggests that if passengers are satisfied with this attribute, they are less likely to rate the service as 'Poor' relative to the reference alternative – 'satisfactory'. This is apparent in Figure 3. With regards to *the accessibility of the vehicle*, satisfied passengers are less likely to rate the bus service as 'Poor' or 'Very Poor', indicating that improving the accessibility of the bus services may increase overall satisfaction. Similar results are obtained with regards to *the noise level of the bus* and *vehicle condition*. With regards to the *punctuality of the bus service*, when passengers are satisfied with this aspect, they are more likely to rate the service as 'Excellent' or 'Good'. This indicates that providing a punctual service may increase passenger satisfaction. The results on satisfaction with the *comfort level of the bus* are perhaps the strongest. When passengers are satisfied with the comfort level, they are much more likely to rate the service as 'Excellent' or 'Good' and much less likely to rate the service as 'Poor' or 'Very poor'. The relative risk of choosing the 'excellent/good' satisfaction level over the reference alternative (i.e. the 'satisfactory' category) is exp(1.47) = 4.3 for satisfied customers relative to dissatisfied respondents. Given the risk ratio of this parameter is significantly larger than 1, it may be suggested that comfort is a very important aspect, to which passengers react strongly. It is probably a good investment to increase the comfort levels of the bus service in order to increase passenger satisfaction.

The finding for the satisfaction indicator variable – *driver skills* indicates that this is a very important attribute of bus service quality. Satisfied respondents are less likely to rate the service as 'poor' or 'very poor' relative to the satisfactory service. The relative risk of choosing the service as 'very poor' over the 'satisfactory' category is 0.33 for satisfied customers relative to dissatisfied passengers.

Figure 2: Conditions of Dhaka's bus transport

Personal characteristics

Several variables for personal characteristics have been tested (e.g. gender, trip purposes, income, age), however only one variable was found to have a statistically significant effect. This is the when passengers use *the bus to go to work or college*. These passengers are less likely to rate the service as 'Excellent' or 'Good', however they are also less likely to rate the service as 'Very poor', which

probably indicates that they have a somewhat neutral opinion about the service level as they may not have access to any other transport modes.

Service characteristics

Information has been gathered on several service characteristics. The *waiting time*, (perceived) *passenger safety from crime* and the *crowded bus service* are found to have significant effects. When waiting time increases, customers seem to be less likely to give a 'Poor' rating to the service relative to the reference category. Waiting time is only significant for the category 'Poor'. The predicted probabilities show that this is the only category where predicted probabilities deviate significantly from the base category (satisfactory). The predicted probabilities for 'Very Poor' have the same 'trend' as the predicted probabilities for satisfactory (see Figure 4). As a result, both satisfactory and very poor have increased predicted probabilities when waiting time increases, whilst 'Poor' has a downward trend and Very good/Excellent stays the same. Perhaps there is a group of people in the sample that is time sensitive and a group that is not.

Figure 4: Predicted probabilities vs waiting time

With regards to levels of safety from crime, this seems to have a large effect when passengers rate the service as 'Excellent' or 'Good'. The relative risk ratio for this parameter is exp(1.32) = 3.7 indicating that (perceived) levels of safety from crimes is an important factor when passengers are satisfied with the provided service. Perhaps it is a good investment to invest in measures aimed at reducing crime especially as only 18% is satisfied with the level of personal safety from crimes. As expected, a passenger is more likely to give a 'very poor; rating to the service quality if the bus is crowded. This is evident from Figure 3 as it shows that the moment when buses arrive to a stop, commuters start pushing and jostling each other to somehow get on board the bus. A reduction in bus overcrowding can be achieved by increasing the number of buses on the road. This is something that Dhaka cannot afford (16).

Random parameters

Even though two parameters were found to be random, there is an increase in log likelihood of less than two units. This is not statistically significant and does not warrant an extension of the model to include random parameters. Therefore, the multinomial logit model should be seen as superior.

POLICY IMPLICATIONS AND DISCUSSION

In general, the respondents in the sample rate service quality poorly. The most important contributor towards the poor and very poor perceptions are the comfort level and driver skills. The finding on comfort level is important, as it stresses the importance of providing buses that are fit for purpose. Findings on vehicle condition, noise levels and accessibility reinforce this conclusion, buses need to be safe, comfortable and fit for purpose. The data indicates that this drives dissatisfaction for many respondents. The finding on driver skills is important as well, it indicates the need to have competent drivers. A less important indicator of dissatisfaction seems to be the perceived level of crowdedness of the bus service. The low impact may suggest that bus passengers in Dhaka city assume bus services to be crowded in any event.

When passengers rate the bus service as 'excellent' or 'good', the main drivers behind this rating seem to be the comfort level and the safety with respect to crime of the bus service. This finding is also confirmed by some existing studies (e.g. 17, 20, 21, 22). It would be interesting to further explore the finding on passenger safety for the case of Dhaka; perhaps this plays a more important role for females as compared to males. Given that only 18% are satisfied with the level of safety with regards to crime, this is clearly an area of concern. The finding on comfort level again stresses the importance of this attribute. Passengers react strongly to their perception of comfort level, thus if a bus operator in Dhaka aims to improve quality, this is a key attribute to focus on. Another finding is that when punctuality is perceived as satisfactory, the passengers are more likely to rate the service as good/excellent. This finding is in-line with the study by dell'Olio et al. (41). The descriptive statistics show that average waiting time for buses is rather long, so perhaps improving the levels of punctuality may help bringing down these waiting times, as well as improving passenger satisfaction. With regards to personal characteristics, when passengers use the bus to go to work, they are less likely to rate the service as 'good' or 'excellent'. These are usually passengers that use the bus on a frequent basis and in order to improve quality, it might be beneficial to focus on the needs of these passengers. Modelling results indicate that bus passengers in Dhaka do not like the crowded buses. However, the majority will continue to use the crowded bus system as they are not willing to pay extra for better services (16). A reduction in bus overcrowding can be achieved by increasing the number of buses on the road. This is something that Dhaka cannot afford.

The study thus provides some interesting insights with regards to bus services in developing nations. Studies conducted in developed countries usually find that punctuality, frequency, comfort and speed are the most important factors affecting perceived service quality. In this setting however, only the role of comfort seems to be a really important driver. This perhaps indicates that passengers in developing countries have different expectations with regards to the bus service as compared to passengers in developed countries.

It is to a certain degree surprising that the mixed logit model was found to be less preferable than the MNL model in analysing the satisfaction levels of bus passengers in Dhaka. As a developing megacity, one would expect that there would be a significant variation among its bus passengers regarding their perceptions and preferences of bus service quality. Yet it may be that bus users in Dhaka who responded to the survey represent a homogeneous low-income group of residents who do not have access to any other transport modes. Therefore, the inherent taste heterogeneity is negligible (see Figure 3). Alternatively, it might have been difficult to capture this heterogeneity due to lack of latent intangible factors not measured in the customers' survey data.

This study has some limitations. The most important limitation is that the study quantifies the impact of satisfaction ratings with individual attributes on overall satisfaction but does not explain them. The results indicate, for instance, that passengers are more likely to rate the bus service as good or excellent when passengers perceive the bus service as safe with regards to crime, however we do not know why they perceive the bus service as safe in these instances. This makes it difficult to quantify the benefits of policies aimed at improving perceived quality of the bus service. Further research could focus on the 'why' behind these ratings.

Another limitation lies in the sample composition and size. The descriptive statistics indicate that a significant part of the sample consists of 'captive' users, who either have no alternative or no

car. The opinion of non-users is not measured. The perception of non-users is, however, very relevant, as improving service quality is usually done to increase the market share. The results from this paper indicate that respondents are homogeneous in their opinions, which may be the case for non-users as well. Another limitation is that the survey did not ask questions about transport coverage or competition. In some parts of the city, modes such as tempo (motorized paratransit) and rikshaws (non-motorized paratransit) might be a competitor to the bus services, which perhaps induces bus companies to offer more quality on these routes.

Finally, the sample is skewed towards males (around 70%), which could either be because females are less likely to respond to surveys or because they are a minority of bus users in Dhaka. The opinions of females are very relevant however, as they may react differently to attributes related to passenger safety as compared to males.

CONCLUSION

Being a megacity of a developing nation, the development of Dhaka's bus transport has been primarily organic in its structure and subject to scarce resources, inadequate strategic planning and regulations. To improve bus service quality, there has been an increasing emphasis on the better understanding of the factors that affect customers' satisfaction and perception in both developed and developing nations. This paper analysed bus passengers' satisfaction using a customer satisfaction survey with a sample size of 955 and identified important factors impacting on service quality to formulating policies and regulations. Overall, bus passengers in Dhaka are not satisfied with the service quality: less than 1% of the customers rated the service as 'excellent' and only 9% rated the service as 'good'. In addition, if we were to randomly choose a bus passenger in Dhaka, the expected score of bus service quality was found to be only 2.22 on a scale of 1 ('very poor') to 4 ('excellent/good').

Service quality attributes that have a positive significant impact towards the excellent/good perceptions of bus service in Dhaka are: the *punctuality of the service,* the *comfort level* and *(perceived) levels of safety from crimes.* More specifically, it was found that satisfied bus passengers with regards to *punctuality of the service* are more likely to rate the service as 'excellent/good' relative to the 'satisfactory' service category with a risk ratio 1.93. This indicates that compared to dissatisfied respondents, satisfied passengers are 1.93 times more likely to choose the excellent/good category over the reference category. Regulations and policies should be formulated to provide a punctual bus service that will increase passenger satisfaction and service quality. Another important finding relates to the satisfaction indicator – *driver skills*. This factor is directly associated with comfort level and vehicle conditions. It can perhaps be concluded that aspects related to the *comfort* and *condition of the vehicle* as well as *driver skills* are the most basic factors that bus service providers in Dhaka have to focus on in developing a safe and reliable bus transport system.

Author contribution statement:

The authors confirm contribution to the paper as follows: study conception and design: Rahman, Quddus; data collection: Rahman; analysis and interpretation of results: Monsuur, Quddus; draft manuscript preparation: Quddus, Monsuur, Rahman, de Ona, Enoch. All authors reviewed the results and approved the final version of the manuscript.

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