MEASURING THE INFLUENCE OF THE PERCEIVED BUS TRANSIT QUALITY ON THE PERCEPTIONS OF USERS

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ABSTRACT

This paper presents quantified evidence on the influence of perceived performance quality of bus service on the perceptions of users. The study draws upon a data set of 512 questionnaires distributed across Belfast city, UK. A binary logistic regression and Analytical Hierarchy Process (AHP) models are developed to quantify the impact of the relationships between the perceived performance quality from 29 indicators of bus service, and the overall perceptions of users towards the service. The findings of the paper show a significant variation on the perceptions held by different categories of users, and indicate 11 quality indicators that have a significant influence on the perceptions of users. These findings provide policy makers and operators with quantified indications of the required quality improvements if we are to promote the use of sustainable modes or transport.
Keywords: User perception, bus quality, logistic regression, analytical hierarchy process

INTRODUCTION

The quality of bus transit services represents a fundamental aspect for promoting the use of bus transit service in order to alleviate the problems resulting from the accelerated car dependency. The current desire for economical recession in many developed countries has imposed several demands on decision makers to rationalise and justify public expenditure. Accordingly, it is imperative for decision makers to identify the critical attributes of bus services quality that have significant influence on the perceptions of different categories of users, as well as, on their mode choice process (Beirão and Sarsfield Cabral, 2007, Eboli and Mazzulla, 2007).

In practice, both benchmarking tools and quality monitoring models are operationalised to investigate the quality of bus service from two different perspectives. The former has been implemented to objectively address the level of quality delivered by service providers (e.g. productivity, efficiency, and effectiveness), while the later has been implemented to subjectively investigate the quality level perceived by users through the evaluation of perception, attitude, satisfaction, and preference (Nathanail, 2008; Transportation Research Board, 1999).

However, the complexity of bus quality management process emerges from the multidimensional dynamic interrelationships between these two parameters and the side effects of performance quality on user perception. This conflict represents an area of lacking research which forms the basis of this study to firstly, measure the perceptions of both current and potential users towards bus quality, as well as, the perceived performance quality of bus service, and secondly, to measure the influence of the performance quality on the likelihood of users to be in high/low perception tier.

The study is organised as follows: firstly, the following section reviews the current practices of bus quality management and draws upon two areas of bus quality namely perception-based and performance-based quality measures. Secondly, the methodology section illustrates the context of the study, data collection, sampling, and the analytical methods employed in the study. Thirdly, the results of user perception, performance quality, and the linking model are introduced in the result section. Lastly, the study concludes by discussing the potential scenarios for developing bus service quality with user perception.

CURRENT PRACTICE OF BUS QUALITY MANAGEMENT

The term service quality in the context of public transport has been defined as the measure of how well the delivered service matches customer expectations (Eboli and Mazzulla, 2008, Transportation Research Board, 1999). The Quality Loop model of public transit has defined the term service quality in two distinct forms. From service provider's perspective, service quality is the measure of how well the delivered quality matches the targeted quality. In contrast, from the customers' perspective, it is a measure of how well the perceived quality matches the desired quality (Nathanail, 2008, Transportation Research Board, 2003). Accordingly, two distinct streams of research have been carried out to address the complexity of bus quality. These include perception-based and performance-based quality measures.

Perception-based measures have been operationalised (qualitatively and/or quantitatively) to measure the perceptions, attitudes, preferences, and satisfaction of users towards the quality of bus services (dell'Olio et al., 2010, Iseki and Taylor, 2010, Tyrinopoulos and Antoniou, 2008).

In practice, perception-based quality measures have been operationalised through the evaluation of both preference and satisfaction (Lai and Chen, 2011, Mahmoud and Hine, In Press-b, Oliver, 2010). However, several research studies have argued that separately neither preference nor satisfaction can provide a comprehensive valuation of user perception (Eboli and Mazzulla, 2011, Oliver, 2010). As a result, the integration of preference and satisfaction has also been implemented to define user perception, and to identify the service attributes that influence the perceptions of different categories of users (Stradling et al., 2007). While, performance-based quality measures, in the context of bus quality loop, have been employed to measure of the gap between the delivered and the targeted quality, and to measure the productivity, efficiency, and effectiveness of service performance (Eboli and Mazzulla, 2011, Fielding et al., 1985).

It is evident from the review that numerous measures and parameters of service quality have been implemented that represent internal measures of quality (service providers), as well as external measures of quality (customer perception) as detailed in Figure 1 (Quattro, 1998). However, it could be seen that although the inclusion of both external and internal measures in the quality appraisal is essential, the former represent the threshold and the starting point of the quality loop (Eboli and Mazzulla, 2011, Mahmoud and Hine, In Press-b, Nathanail, 2008). Therefore, the internal quality standards (targeted and delivered quality) should accommodate the desires and perceptions of users if service patronage is to be improved.

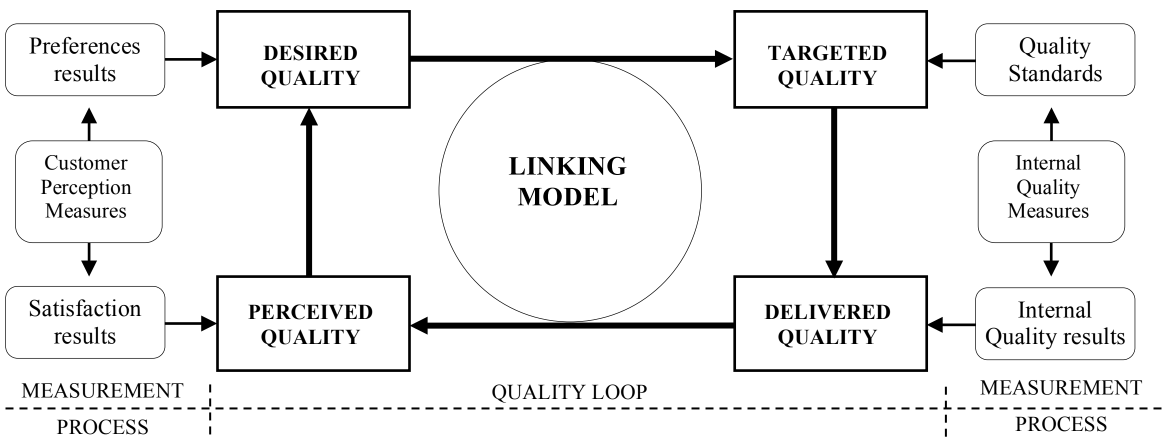

Figure 1 – Quality management process of bus service

Accordingly, attempts have been made to investigate the linkages between the perceptions of users and the performance of bus service. Such studies analyse the influence of performance quality on the perceptions and the behavioural intentions of different categories of users (Friman, 2004, Lai and Chen, 2011).

However, Sheth and colleagues (2007) have argued that evaluating the quality of bus service is very complex to be explained with a composite measure. They have pointed out two forms of complexity namely, detailed complexity and dynamic complexity. They stated that: “This complexity arises from the fact that multiple factors and goals should be considered concurrently (detailed complexity). Additionally, there are multiple interactions that need to be captured and understood (dynamic complexity)” (Sheth et al., 2007: pp. 454).

Accordingly, this study argues that due to the dynamic interrelationships between performance and perception measures, the evaluation of bus quality should not be limited to the average of both measures. Rather, it should address the influences of the performance quality level of the service on users' perceptions and attitudes. Accordingly, this study differs from the current literature in that; firstly it is not limited to the perceptions of current users, and it includes both current and potential users. Secondly, it integrates both satisfaction and preference evaluation and develops a weighted perception index. Thirdly, it measures the influence of the performance quality of various bus attributes on the likelihood of users to have high/low perception towards bus service.

METHODOLOGY

Data and Sampling

This study draws upon the perspectives of both current and potential users for evaluating bus service quality. In this respect, current user refers to individuals who regularly use bus services as their main travel mode, while potential user refers to individuals who regularly use private cars as their main travel mode and occasionally use bus service. And the study focuses on Translink bus services in Belfast City (UK) that include Metro and Ulster Bus.

The data collection process focuses on three measures of bus quality that include user preference, satisfaction, and the perceived performance quality from the service. Both preference and satisfaction measures are incorporated to address user perception towards bus quality. While, performance quality is utilised to address the objective quality of bus service.

The study utilises a set of 29 indicators that were derived using focus group discussions and expert panel analysis for all stakeholders. This process is detailed at length in (Mahmoud and Hine, In Press-a). The 29 quality indicators are classified into six main attributes; namely service design, access to the service, operation, fare, information & facilities, and safety & security as detailed in Table 1.

A questionnaire survey was developed, piloted, and distributed across Belfast City, UK through three approaches: household, online, and intercept at the main transport hubs (stop, on-board, and terminals). The study employed different sampling measures. This ensures that firstly, the collected data fulfils the minimum sampling requirement for each analytical method. Almost 1,000 questionnaires were distributed, and 512 complete and valid questionnaires were used in the analysis. The collected sample ensured firstly, the balance between current and potential users, and secondly, the diversity of the socio-economic variables as detailed in Table 2. Moreover, the diversity of geographical location (rural and urban) was taken into consideration to ensure that different constraints and opportunities are accounted for.

Table 1 – Bus quality indicators

Main Attributes	Code	Indicators	Code
Service Design	SD	- The comfort, cleanliness, and crowding of the bus	SD_COB
		- Need for transfers	SD_NFT
		- Driver attitude & helpfulness	SD_DAH
		- Route (Network area covered)	SD_NAC
Access to service	AS	- Ease of access stops (routes & infrastructure)	AS_EAS
		- Bus stop location and distance between stops	AS_BSL
		- Handicap access installations	AS_HAI
		- External interface to pedestrians, cyclists, car & taxi	AS_EIP
		- Availability of park and ride schemes	AS_APR
Operation	OP	- Waiting & transfer time	OI_WTT
		- Boarding & Alighting time	OI_BAT
		- Total travel time	OI_TTT
		- Reliability of the service (arrival time)	OI_ROS
		- Operating hours	OI_SOH
		- Frequency (Weekly, weekend, and holidays)	OI_FOS
Information & Facilities	IF	- Availability of shelters, benches and waiting areas at stop	IF_ABW
		- Availability of amenities (Enquiries points, sanitary, refreshment) at terminals	IF_AVA
		- Information during travel (Real time information)	IF_IDT
		- Availability of information at station (signs, schedule and maps)	IF_IAS
		- Pre–trip information (phone & web)	IF_PTI
Fare	FA	- Bus fare	FA_BFA
		- Availability of multiple-mode tickets	FA_AMP
		- Ease of purchasing tickets (on board, at stops, at terminals)	FA_EPT
		- Availability of monthly discount passes	FA_AMD
Safety & Security	SS	- Visible monitoring (CCTV)	SS_CTV
		- Lighting, noise, vibration, speed, and temperature on bus	SS_LNV
		- Safety during trip (Day & night)	SS_SDT
		- Absence of offensive	SS_AOO
		- Security against crimes on bus & at stops	SS_SAC

Table 2 – Socio-economic & travel behaviour characteristics of respondents

Socio-economic & travel behaviour variables		Frequency	Percentage
Gender	- Male	240	46.9%
	- Female	272	53.1%
Age	- less than 20	176	34.4%
	- 21–60	276	53.9%
	- More than 60	60	11.7%
Annual income	- Less than 10000	202	39.5%
	- 10000–30000	184	35.9%
	- 30000–60000	112	21.9%
	- More than 60000	14	2.7%
Occupation	- Employed	297	58.0%
	- Unemployed	215	42.0%
Place of living	- City centre	57	11.1%
	- Urban	166	32.4%
	- Sub–urban	150	29.4%
	- Periphery & rural	139	27.1%
Driving licence	- Yes	400	78.1%
	- No	112	21.9%
Car ownership	- Yes	332	64.8%
	- No	180	35.2%
Travel mode	- Frequent bus user	239	46.7%
	- Frequent car user	273	53.3%
No of trips / week	- 1–5	139	27.1%
	- 6–10	169	33.0%
	- More than 10	204	39.8%

Analytic Hierarchy process and statistical analysis

The study employs a mixed method design that utilises two methods namely; the Analytical Hierarchy Process (AHP) and Binary Logistic Regression (BLR) in a two-step design. Firstly, AHP is employed to derive user (current and potential) preference for bus attributes and to develop a weighted perception measure that combines both preference and satisfaction in a single output model. Secondly, a BLR model is developed to investigate the influence of the perceived performance quality on the likelihood of user to have high/low perception towards the service Field, 2009, Hair et al., 2010, Tabachnick and Fidell, 2007).

The AHP method is carried out in two main stages including hierarchy structure and Eigenvalue Method (EM) of weight election (Saaty, 1996, Saaty and Vargas, 2000). Accordingly, a hierarchical model that utilises 29 indicators classified into six attributes is developed as illustrated in Figure 2. Accordingly, user preferences are derived through a series of pairwise comparisons within the two layers (attributes and indicators).

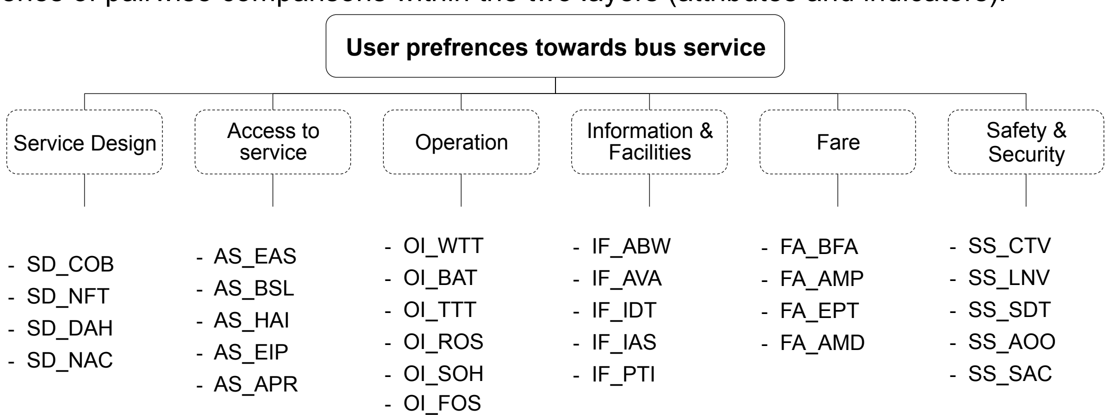

Figure 2 – AHP hierarchy for measuring user preferences towards bus service

In addition, a weighted perception index (WPI) that combines both preference and satisfaction measures into a single output tool is developed. The weighted perception index draws upon the AHP-weight (preferences), and the stated satisfaction values for each indicator/attribute. Therefore, the weighted perception index for (n) criteria is calculated as follows (Ho et al., 2005, Schniederjans et al., 2004):

$$WPI = \sum {}^{(RW_1 * SAT_1 : RW_n * SAT_n)}/_{n}$$

Where, WPI= weighted perception index, SAT= satisfaction score for indicators, RW= relative weight of indicators, and n= number of indicators.

Secondly, a BLR model is structured using the WPI as a dependent categorical variable with two tiers of perceptions: high perception tier (WPI values are greater than the mean of all respondents), and low perception tier (WPI values are lower than the mean of all respondents). The performance quality measures of 29 indicators are used as metric independent variables. Therefore, the WPI values are recoded using a binary code, whereby a high perception tier = 1, and a low perception tier = 0.

RESULTS

Perception towards bus quality

The results of the AHP overall model have revealed user preferences for bus services for both the main attributes and indicator levels. Firstly, the results of the main attributes indicate that safety and security (SS= 0.2339) are of a relatively high importance, followed by fares (FA= 0.1952) and operational (OP= 0.1900) attributes. The results also indicate that the service design (SD= 0.1084) is relatively less important as detailed in Figure 5. However, it could be seen from the results that no single attribute is dominant, and all six attributes contribute to users' preferences towards the bus service. On the other hand, the results of the indicators level indicate that six indicators represent the main preferences of users. These indicators are security against crime (SS_SAC= 0.083), the availability of multi-mode tickets (FA_AMP=0.074), bus fare (FA_BFA= 0.069), the frequency of service (OI_FOS= 0.061), the reliability of service (OI_ROS= 0.053), and bus stop location (AS_BSL= 0.048). Three indicators have the lowest preference scores including the availability of amenities (IF_AVA= 0.008), boarding and alighting time (OP_BAT= 0.006), and information during travel (IF_IDT= 0.014).

The results of user satisfaction analysis indicate that users are more satisfied with indicators associated with safety and security, and information and facilities. However, they are less satisfied with indicators associated with service design, and operational attributes. These results are clearly reflected in the indicators level, with higher satisfaction assigned to security against crime, and security during travel. Lower satisfaction values were assigned to the comfort of buses, the network area coverage, the need for transfer, driver attitude, the reliability of service, and frequency of service.

However, the integration of both satisfaction and preference results generates new patterns of a weighted perception index (WPI). The results of the WPI for the main attributes level (Figure 7) show that safety and security (WPI_SS= 8.46), fares (WPI_FA= 6.45), and operational (WPI_OP= 5.98) attributes contribute the most to shaping users' perceptions of the bus service. While, service design (WPI_SD= 3.08), information and facilities (WPI_IF= 3.85), and access to service (WPI_AC= 5.15) make less of a contribution to users' perceptions. Meanwhile, the results of the indicators level show that security against crime (WPI_SS_SAC= 14.47), the availability of multi–mode tickets (WPI_FA_AMP= 12.09), and bus fares (WPI_FA_BFA= 10.36) make the most contributions towards users' perceptions as illustrated in Figure 3. The results highlight the significant impact of preferences over the weighted perception index. Although users have assigned almost the same stated satisfaction values for some indicators, the impact of preferences generates new composition of weighted perception for both the attribute and indicator levels.

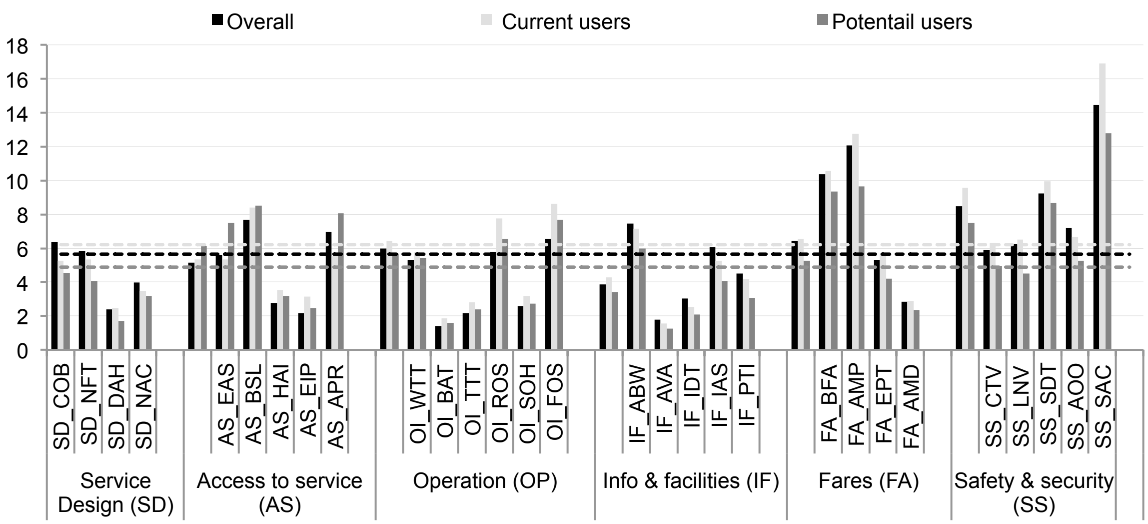

Figure 3 – users' perceptions towards bus service

Perceived performance quality of bus service

The performance quality result indicates that the overall performance quality level of the service is moderate with an overall performance quality value of (Q_OVALL= 4.83). This result is clearly reflected in both the indicator and attribute levels. For the attribute level, the results show that two attributes are regarded as providing relatively higher performance quality; namely service design (Q_SD= 5.31), and safety and security (Q_SS= 5.24). In contrast, two attributes are regarded as having lower performance quality: fares (Q_FA= 4.42), and access to service (Q_AS= 4.45). While for the indicators level, the results indicate that several indicators are regarded as providing relatively higher quality performance; these include security against crime (Q_ SS_SAC= 5.85), information at stops or stations (Q_ IF_IAS = 5.37), and the availability of CCTV (Q_SS_CTV= 5.46). Three indicators are clearly regarded as providing relatively lower quality performance values: these are frequency of service (Q_OI_FOS= 3.96), bus stop location (Q_ AS_BSL= 3.99), and the availability of monthly discounts (Q_ FA_AMD= 4.09).

Performance indicators influencing user perception

Investigating the quality drivers and/or barriers to user perception offers in-depth knowledge that can be utilised to optimise bus service quality. The development of the weighted perception index (WPI) offers the option of classifying users based on their perceptions towards the service. Accordingly, the WPI values of all participants are transformed into a categorical variable that represents two segments of perception. The first segment represents a high perception tier, and the second segment represents a low perception tier. The overall WPI score for all participants (5.437) is used as a threshold to define the range of each tier. Accordingly, all variables within the range of high perception tier (10≥high tier≥5.437) are transformed into a dummy variable with a value of Y=1, while all variables with the range of low perception tier (5.437>Low tier>0) are transformed into a dummy variable with a value of Y=0.

The results of the model summary – Omnibus tests of model coefficients – indicate that the model is statistically significant at $p \leq 0.0001$, chi-square= 486.518, and df= 5.0. In total, the model explained a range, from 60.0% (Cox and Snell R^2) to 80.3% (Nagelkerke R^2), of the impact of performance quality over user perception, and classified 91.6% of the cases. In addition, the calculation of the overall model fit (pseudo R^2) indicates a considerable goodness-of-fit for the BRL model with $R^2_{LOGIT} = 0.666$.

The BLR results (Table 3) indicate 11 (37.93 %) performance quality indicators that have a significant impact on users' perceptions. The values of the original coefficient (B), and the exponentiated coefficient (Exp.B) indicate that two variables have a relatively higher influence on users' perceptions; namely the need for transfer (B= 0.895, Exp.B= 2.446), and the frequency of the service (B= 0.734, Exp.B= 2.083). The model shows that a unit increase of the performance quality of the need for transfer variable results in an increase of the odds by 85.5%.

Table 2 – The impact of performance quality on user perception

Variables in equation		B	S.E.	Wald	df	Sig.	Exp(B)
Comfort of bus	QU_SD_COB	0.238	0.114	4.321	1	0.038*	1.269
Need for transfer	QU_SD_NFT	0.895	0.177	25.616	1	0.000***	2.446
Driver attitude	QU_SD_DAH	0.069	0.110	0.396	1	0.529	1.072
Network area coverage	QU_SD_NAC	-0.048	0.137	0.122	1	0.727	0.953
Ease of access	QU_AS_EAS	-0.112	0.095	1.401	1	0.237	0.894
Bus stop location	QU_AS_BSL	0.359	0.130	7.627	1	0.006**	1.432
Disabled access	QU_AS_HAI	0.573	1.425	0.162	1	0.688	1.774
External interfaces	QU_AS_EIP	-0.513	1.429	0.129	1	0.720	0.599
Park & ride schemes	QU_AS_APR	0.560	0.142	15.596	1	0.000***	1.750
Waiting & transfer time	QU_OI_WTT	0.380	0.135	7.891	1	0.005**	1.462
Boarding & alighting time	QU_OI_BAT	-0.143	0.121	1.387	1	0.239	0.867
Total travel time	QU_OI_TTT	0.001	0.162	0.000	1	0.997	1.001
Reliability of service	QU_OI_ROS	0.524	0.126	17.246	1	0.000***	1.689
Operation hours	QU_OI_SOH	0.211	0.117	3.263	1	0.071	1.235
Frequency of service	QU_OI_FOS	0.734	0.126	33.775	1	0.000***	2.083
Waiting areas	QU_IF_ABW	0.033	0.093	0.123	1	0.726	1.033
Availability of amenities	QU_IF_AVA	0.119	0.090	1.745	1	0.187	1.126
Information during travel	QU_IF_IDT	1.766	19.391	0.008	1	0.927	5.845
Information at stop	QU_IF_IAS	0.250	0.092	7.389	1	0.007**	1.284
Pre-trip information	QU_IF_PTI	-1.722	19.392	0.008	1	0.929	0.179
Bus fares	QU_FA_BFA	0.432	0.144	8.954	1	0.003**	1.540
Multi-operators tickets	QU_FA_AMP	0.195	0.105	3.480	1	0.062	1.216
Ease of purchasing	QU_FA_EPT	-0.050	0.126	0.160	1	0.689	0.951
Discounted tickets	QU_FA_AMD	0.397	0.129	9.450	1	0.002**	1.487
CCTV monitoring	QU_SS_CTV	0.180	0.101	3.154	1	0.076	1.197
Lighting, noise, vibration	QU_SS_LNV	0.107	0.101	1.117	1	0.291	1.112
Safety during travel	QU_SS_SDT	-0.009	0.098	0.008	1	0.927	0.991
Absence of offensives	QU_SS_AOO	0.126	0.123	1.062	1	0.303	1.135
Safety at stops/stations	QU_SS_SAC	0.380	0.132	8.245	1	0.004**	1.462
	Constant	-27.874					
	Cox & Snell R^2	0.600					
	Nagelkerke R^2	0.803					
	R^2_L	0.666					

*** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Further inspection of the results indicates that all significant indicators have a positive relationship (+B value) with user perceptions. In other words, an increase in the quality level of these indicators will result an enhancement of user perception towards the bus service. In addition, the ranking of the significant indicators indicates that both the need for transfer and the frequency of the service have the most influence on user perception. In contrast, both information at the stop/ or station and the comfort of the bus have a relatively low, but significant, influence on user perception.

In this respect, firstly, the probabilities of all participants are calculated, and secondly, the probabilities of both current and potential users are derived to investigate the gap between different categories of users. The result indicates the overall probability of a user to be in high perception tier P(Y=1) is 67.37%. However, the modal split of both current and potential users indicates that; current users have 85.33% probability to be in high perception tier, while potential users have a 45.13% probability to be in high perception tier. These findings show the influence of performance quality on the perceptions of both current and potential users. Moreover, they highlight the need for optimising performance quality in a way that can accommodate the level of service required by different categories of users. These findings support the theoretical argument that performance quality has a significant influence on user perception (Chen, 2008, Eboli and Mazzulla, 2007, Friman, 2004, Lai and Chen, 2011).

CONCLUSION

The practical relevance of the study offers methods for optimising bus service quality with the perceptions of different categories of users. The individual analysis of both subjective (perception) and objective (performance) quality presented evidence for bus quality evaluation that separately analyse the perceptions of users towards the service and the perceived performance quality delivered by service providers. However, the combination of both measures offered an in-depth understanding of the linkages between both measures. The findings of this study provide a comprehensive tool for evaluating bus service quality that considers the dynamic relationship between both subjective and objective parameters. In this respect, the study concludes by identifying 11 indicators are included that significantly influence the perceptions of both current and potential users.

These findings provide a feasible approach to enhancing the perceptions of different categories of users towards bus services; the measures suggested could be readily implemented, if policymakers are to increase passenger patronage through a behavioural shift from car to bus service, by analysing the impact of each indicator on user perception with the corresponding cost for improving its performance quality. In addition, the findings offer policy makers with clear indications for the development of market-oriented policy packages that consider the differential demands/desires of different segments in the market (e.g. current and potential users).

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