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## Passenger satisfaction towards metro infrastructures, facilities and services

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### Abstract

Public attitudes towards public transport (PT) services will be very important when it comes to improving demand for those services. Therefore, local authorities as well as transport providers make a significant effort to improve passenger satisfaction towards the PT services by enhancing the quality of service. The present study investigates the satisfaction that passengers gain from Tyne and Wear Metro (TW-Metro) services. In this study, the data collected by a questionnaire survey was analysed by Principal Component Analysis (PCA) and Cross Tabulation Analysis (CTA) to explore the effect of passengers' perception of various factors that influence passenger satisfaction.

The findings are based on the responses of passengers to the questionnaire designed for assessing service quality based on fifteen different attributes. The PCA shows that three significant factors in predicting passenger satisfaction such as security, safety and comfort, infrastructure quality, and ticket purchase facilities. The CTA shows that there is a significant difference between satisfaction scores and demographic profiles, in particular age, gender, professional/employment status and frequency of use of Metro services. The outcome of this study will be useful for public agencies for improving quality of service in PT services.

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*Keywords:* Public transport, metro services, passenger satisfaction, principle component analysis, cross tabulation analysis

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### 1. INTRODUCTION

In order to create greener and more liveable cities, decision makers across the world crucially need to change the direction of urban transport development towards a more sustainable future. Establishing a sustainable urban transport system requires a comprehensive and integrated approach to both policy making and decision-making, with the common goal of reinforcing affordable, economically viable, people-oriented and environment-friendly transport system (Goldman and Gorham, 2006; Richardson, 2005). No doubt that most of the cities across the world do not have potential to increase road infrastructure to confront growing population. As a result, one of the greatest challenges experienced by most of the cities is congestion. Congestion is problematic because it results in a cascade of further consequences covering economic, environmental and social aspects such as travel delays, air quality, traffic accidents and public health concerns. It is essential that sufficient infrastructure and adequate management plan be introduced to deal with the increasing transport requirements. Public agencies therefore need to investigate what aspects of improvements to their service can be undertaken in order to enhance current customers experience as well as attract potential customers. Public transport customers' level of satisfaction significantly affects their decision making when choosing their primary travel option over personal modes (TriMet, 1995).

Considered as the most significant factor of both consumer attitude and customer loyalty (Olsen, 2007), quality of service delivery has a significant impact on customer satisfaction (Kilibarda et al., 2017). The initial steps in improving customer satisfaction begin with assessing service quality (Aydin et al., 2017). Hence it is essential for public agencies to determine service quality requirements (de Ona et al., 2016), thereby fulfilling customer expectations by delivering quality services (Parasuraman et al., 1988). Concurrently, delivering basic

expected service quality is insufficient as consistent performance and innovation are driving forces behind customer satisfaction. Aydin et al., (2017) has indicated that assuring high level of customer satisfaction is the goal for public agencies.

In recent years, management of public transport quality has emerged as a subject of comprehensive research. Profitability of public transport system is dependent upon the service delivery, while the quality of service provided therein is a reflection of one's perception and expectations regarding performance (Machado-Leon et al., 2017). Evaluation and enhancement of transportation systems towards service quality and customer satisfaction is of considerable importance. Eboli and Mazzulla (2009a,b) conclude that customers having a positive experience with transit performance (or any business) are more likely to use such services again, possibly due to the underlying assumption that the actual service quality is linked to customers' perception of the service (Friman and Felleson, 2009). Essentially, this pushes transit operators to continually conduct detailed surveys in order to ascertain the areas that lead to passenger satisfaction (Verbich and Ei-Geneidy, 2016).

Measuring passenger satisfaction on public transport services is essential in both transportation research and practice (Ranaweera and Prabhu, 2003). To improve the infrastructures, facilities, services as well as demand for public transport, transit agencies require to understand how much passenger expectations have actually been fulfilled. Customer surveys become imperative as they provide transit agencies with valuable information such as facets which are considerable of importance for passengers and what they are satisfied and dissatisfied about in particular (Le-Klähn et al., 2014; Lai and Chen, 2011; Mouwen, 2015).

The next section presents the critical review of existing literature on satisfaction out of public transportation services; railway stations, railway transit services and railway platforms. Review of different methodologies and its application across the industries and definition of customer satisfaction factors have also been presented in separate sub-sections. This is followed by steps of methodology that have been adopted, data analysis and in-depth discussion. This paper ends with conclusions and recommendations for future research.

## 2. LITERATURE REVIEW

This section features a summary of past studies on satisfaction derived by passengers related to the railways and platforms of railway stations, followed by methodologies adopted in previous studies.

### *Critical Review of Service Quality Attributes that Contributes for Passenger Satisfaction*

Table 1 presents the findings of previous research with respect to quality related attributes that enhance passenger satisfaction. The research by Pratminingsih et al. (2014) have identified perceived value, perceived quality, trust, passenger loyalty and passenger satisfaction are suitable indicators when measuring the overall service quality of public transport. Of these, passenger satisfaction and trust have emerged to be significantly influence passenger loyalty. Celik et al. (2014) have studied rail transit network (metro, tram, light rail and funicular) in Istanbul. Passengers were found to be the most dissatisfied with crowd level, noise level, air-conditioning inside the train and vibration during the journey of a total of twenty-six attributes.

Lai and Chen (2011) emphasised that the factors such as perceived value, service quality and satisfaction as important when assessing the relationship between involvement of public transit services and behavioural intentions of passengers. Causal relationship between them was emerged to be statistically significant. de Oña et al. (2016) have identified seven factors covering twenty-seven attributes towards identifying the attributes used by passengers for evaluating quality of railway services in Milan, North Italy. The most significant attributes were security provisions board, security provisions at station and safe travel. Nathanail (2008) investigated the influence of various dimensions of service quality of Hellenic Railways. Twenty-two attributes were tagged under six evaluation criteria (system safety, itinerary accuracy, passenger comfort, cleanliness, passenger information and servicing). The two most performing attributes as per passenger ratings were system safety and itinerary accuracy.

In another research focused on Metro Rail Transit 3 (MRT3) stations of Metro Manila, Philippines, Doi et al (2003) have identified the reason behind low ridership from both the viewpoint of accessibility and inter-modality. The most significant factor of customers' dissatisfaction is congestion at stations, followed by relatively high fares and inconvenience of transport facilities connecting to other modes of transport. The Gallup Organisation (2011) has confirmed that passengers were the most satisfied with the dimensions of ticket purchase facilities, information provided regarding train schedules/platforms, and personal security at stations. Contrary, car parking facility, quality of facilities and services, and cleanliness/maintenance of station facilities have performed significantly below expectations, thereby leading to dissatisfaction. Ghosh et al. (2017) has taken a total of forty-five factors tagged under seven blocks namely; platform infrastructure and cleanliness, waiting rooms/hall and luggage section, information provision, catering and drinking water, washrooms, toilets and other passenger amenities, passengers' interaction with staff and safety and security of passengers on platforms.

Table 1 Studies focus on satisfaction of rail infrastructure with attention to railway platforms, stations and services

Study	Authors	Objective	Findings		
			Security, Safety & Comfort	Infrastructure Quality	Ticket Purchase Facilities
Retaining Passengers Loyalty in Indonesia Railway Service (Indonesia)	(Pratminingsih et al., 2014)	To assess the overall service quality of railways in Indonesia			
			<i>Comment:</i> Passengers satisfaction and trust were the driving force behind passenger loyalty		
A Multiattribute Customer Satisfaction Evaluation Approach for Rail Transit Network: A Real Case Study for Istanbul, Turkey (Turkey)	(Celik et al., 2014)	To evaluate the performance of service quality to determine how effective and adequate the service is			
			<i>Comment:</i> Railway transportation is one of the most important public transportation types especially in big and crowded cities, i.e., Istanbul		
Behavioral Intentions of Public Transit Passengers—The Roles of Service Quality, Perceived Value, Satisfaction and Involvement (Taiwan)	(Lai and Chen, 2011)	To highlight such behavioral intentions and explores the relationships between passenger behavioral intentions and the various factors that affect them			
			<i>Comment:</i> Causal relationships are statistically significant		
Transit Service Quality Analysis Using Cluster Analysis and Decision Trees: A Step Forward to Personalized marketing in Public Transportation (Spain)	(de Oña et al., 2016)	To extract detailed customer profiles sharing similar appraisals concerning the service			
			<i>Comment:</i> Variables changed when specific groups of passengers are analyzed - Cluster Analysis identifies four groups of passengers		
Measuring the Quality of Service for Passengers on the Hellenic Railways (Greece)	(Nathanail, 2008)	To present a framework developed for assisting railway operators into monitoring and controlling the quality of services provided to their passengers			
			<i>Comment:</i> Grading system has been defined for the appreciation of the indicators and multicriteria evaluation has been developed		
Quantification of Passengers' Preference For Improvement Or Railway Stations Considering Human Latent Traits: A Case Study in Metro Manila (Philippines)	(Doi et al., 2003)	To identify the cause of low light rail transit (LRT) ridership from the viewpoint of accessibility and intermodality			
			<i>Comment:</i> Improvements of pedestrians' accessibility and establishment of transfer terminal between MRT3 and bus are essential		
Survey on Passengers' Satisfaction with Rail Services (European Union)	(The Gallup Organization, 2011)	To examine EU Rail Passengers' Satisfaction with Various Features of the Rail Services, including the Train themselves, Railway Stations and Rail Network in their Country			
			<i>Comment:</i> Very satisfied with ease of buying tickets, provision of information about train schedules and platforms, personal security in the railway station/trains		
Determining passenger satisfaction out of platform-based amenities: A study of Kanpur Railway Station (India)	(Ghosh et al., 2017)	Measures satisfaction that passengers gain out of such amenities through a survey conducted at Kanpur Central station of North Central Railway in India			
			<i>Comment:</i> Basic amenities such as platform infrastructure, cleanliness, catering and drinking water and interaction with railway staff are underperforming resulting in dissatisfaction		

### Critical Review of the Methods for Analysing Service Quality Data

As presented in Table 2, the previous research used variety of methods and methodologies when analysing data related to passenger satisfaction.

Table 2 Review of analytical methods applied in previous studies

Study	Authors	Methodology	Objective
Public Transportation and Customer Satisfaction: The Case of Indian Railways (India)	(Agarwal, 2008)	<ul style="list-style-type: none"> <li>• Factor Analysis</li> <li>• Regression Analysis</li> </ul>	Factor Analysis involved reducing the number of statements to a smaller number of variables which could then be used for further analysis. Regression Analysis was done with the six factor scores as the independent variables and customer satisfaction with Indian Railways as a whole as the dependent variable
A Methodology for Component Level Improvement of Passenger Facilities at the Howrah Railway Station in India (India)	(Gupta and Datta, 2016)	<ul style="list-style-type: none"> <li>• Individual Component-Level Analysis</li> <li>• Path Analysis</li> </ul>	To improve service quality from users' perspective through individual component-level analysis of the attributes that determines the nature of service. Physical attributes and their respective components are individually assessed using Path Analysis
Analysis of Visitor Satisfaction with Public Transport in Munich (Germany)	(Le-Klähn et al., 2014)	<ul style="list-style-type: none"> <li>• Discriminant function analysis</li> <li>• Principal Component Analysis</li> <li>• Reliability Test</li> </ul>	To investigate the use of public transport by visitors in the city of Munich, Germany. It seeks to understand how visitors perceive public transport services and which factors influence their level of satisfaction
Customer Satisfaction in Public Bus Transport: A study of traveller's perception in Indonesia (Indonesia)	(Budiono, 2009)	<ul style="list-style-type: none"> <li>• Correlation Analysis</li> <li>• Factor Analysis</li> <li>• Regression Analysis</li> </ul>	First, correlation analysis was undertaken to measure linear correlation between variables. Then, factor analysis was performed with the aim to identify group or cluster of variables. Third, a regression analysis was performed to evaluate the contribution of each factor on overall satisfaction
Overall Level of Service Measures for Airport Passenger Terminals (Brazil)	(Correria et al., 2008)	<ul style="list-style-type: none"> <li>• Successive Category Method</li> <li>• Regression Analysis</li> </ul>	To identify overall level of service (LOS) measures for airport passenger terminals. Regression analysis is used to obtain mathematical relationships between the quantitative LOS ratings and global indices
Prioritizing Service Attributes for Quality up-gradation of Indian Railway Stations (India)	(Gupta and Datta, 2012)	<ul style="list-style-type: none"> <li>• The Law of Categorical Judgement</li> </ul>	The Law of Categorical Judgement is used to determine levels of importance and levels of satisfaction of disaggregated passenger groups and passengers as a whole. To check the difference in importance levels and satisfaction levels and then prioritize for improvement accordingly
Performance Evaluation of Bangalore Metropolitan Transport Corporation: An Application of Data Envelopment Analysis (India)	(Hanumappa, 2015)	<ul style="list-style-type: none"> <li>• Data Envelopment Analysis</li> </ul>	This approach enabled the identification of opportunities for improvement at the bus depot and route levels
Railqual and Passenger Satisfaction: An Empirical Study in Southern Railways (India)	(Vanniarajan and Stephen, 2008)	<ul style="list-style-type: none"> <li>• RAILQUAL</li> <li>• Factor Analysis</li> <li>• Reliability Test</li> <li>• Multiple Regression Analysis</li> </ul>	Railqual to identify the service quality dimensions in Indian railways (Railqual). Factor Analysis to reduce the number of variables while Reliability Test to test for validity of data for Factor Analysis. Multiple Regression Analysis is adopted to analyse the impact of perception on railqual factors on passenger's satisfaction and their image on Indian Railways

Argawal (2008) utilised both **Factor** and **Regression analysis** to analyse the data and determine the effect of passenger's perception regarding the quality of performance of different factors on passenger's satisfaction. Forty-seven service quality attributes were grouped under six independent variables to measure their relationship with dependent variable. In Indian context Gupta and Datta (2016) have adopted **Path analysis** to identify the contribution of satisfaction in each element in explaining satisfaction in individual attribute. Le-Klähn et al. (2014) applied **Discriminant function analysis (stepwise method)** on sixteen service features of public transport in the city of Munich, Germany. Information, ticket price, service frequency, space inside vehicle, cleanliness of vehicle and ease of use were found to be significantly and positively influence visitor's level of satisfaction.

Budiono (2009) has utilised **Factor Analysis (FA)** to group fourteen specific service quality attributes under two factors, namely, functional factors (price, frequency, travel time and punctuality) and soft factors (on board security, information and seat availability, safety from accidents, bus comfort, staff behaviour, bus stop condition, bus stop security, information at bus stop and cleanliness). Both the functional quality factor and soft quality factor have demonstrated significant positive influence on overall passenger satisfaction with public bus transport services in Indonesia. Correia et al. (2008) have adopted **successive category method** and **Regression analysis** on eight service aspects to determine service quality of terminals at Sao Paulo/Guarulhos International Airport in Brazil. Results indicate that the mean quantitative ratings decrease as the total service time increases.

Gupta and Datta (2012) have adopted **The Law of Categorical Judgement** to identify both the level of importance and satisfaction of various passenger groups as well as all passengers together. **Data envelopment analysis** method is utilised for premium bus services quality evaluation operated by Bangalore Metropolitan Transport Corporation in order to determine opportunities for improvement at bus depot and route levels (Hanumappa et al., 2015). Vanniarajan and Stephen (2008) have analysed various dimensions of service quality of Southern Railways in India perceived by passengers. A total of twenty-five attributes were categorised under five **RAILQUAL** dimensions of reliability, assurance, empathy, tangibles and responsiveness. **RAILQUAL** is an extremely useful tool for performing analysis where a gap is measured as the difference between customer expectations and perceptions.

The data used by previous research are predominantly categorical. Many of them used Likert Scale for collecting the data. Factor analysis is particularly suitable for analysing the data collected via Likert Scales.

### 3. CASE STUDY – TYNE AND WEAR METRO

Tyne and Wear Metro is one of the busiest light rail transit system in the UK outside London which serves five districts, namely, Newcastle upon Tyne, Gateshead, South Tyneside, North Tyneside and Sunderland. The existing network covers 77.5km and has two lines with a total of sixty stations to cater large volume of passenger traffic of around 130,000 and 450 trains operate on the system per day. The ridership number of Tyne and Wear Metro users in the year of 2016-17 was approximately 37.2 million passengers per annum (BBC News, 2017). Figure 1 shows the map of Tyne and Wear Metro.

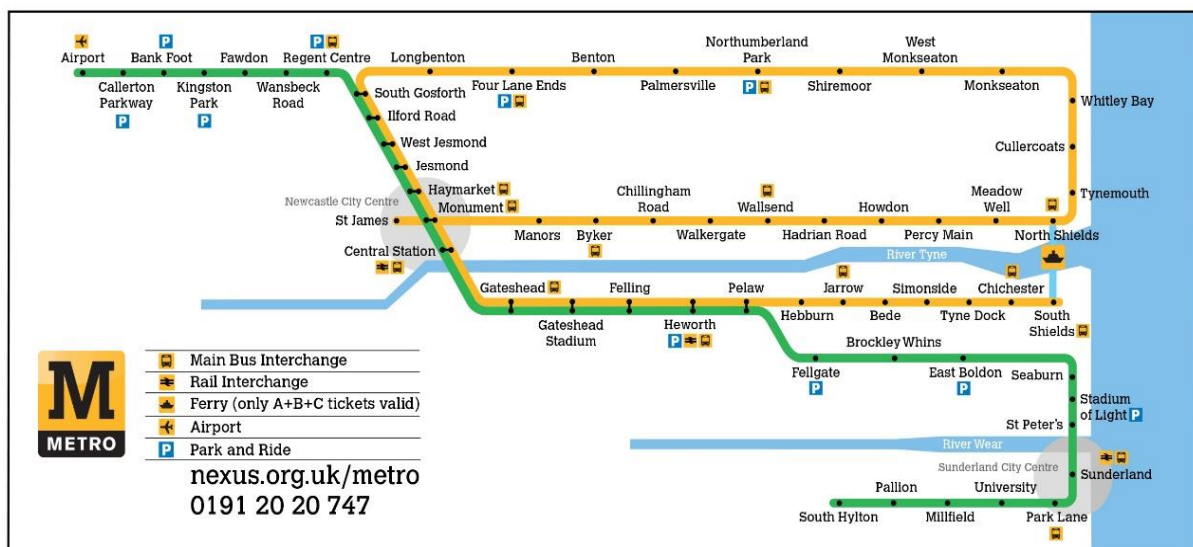


Figure 1: Tyne and Wear Metro Map (Source: Tyne and Wear Metro, 2018)

#### 4. CALCULATION AND VALIDATION OF SAMPLE SIZE

The data collection process spanned over a period of one week where a total of 200 samples were selected for analysis. To determine the statistical validity of the data, Ortúzar and Williumsén (2006) have developed an equation that calculate the sample size required to reflect the overall population. The equation is based on stating a specified precision through a defined confidence level and decided value of error in the result. The sample size is calculated using the following formula:

$$n = \frac{p(1-p)}{\left(\frac{e}{z}\right)^2 + \frac{p(1-p)}{N}}$$

where  $p$  = proportion or incidence of cases,  $e$  = margin of error in result,  $z$  = standardised score for level of confidence, and  $N$  = population size.

The first equation and second equation consider 5% and 10% margin of error respectively. Results indicate that the sample size of 200 adopted for this study falls between 5% and 10% value of error. Hence, it is confirmed that the sample is representative sample which allows the collected results to be generalised to the target population.

#### Methodological Framework

Framework of the methodological approach in this study was developed as shown in Figure 2 which summarises the progress of elements in each phase of methodology.

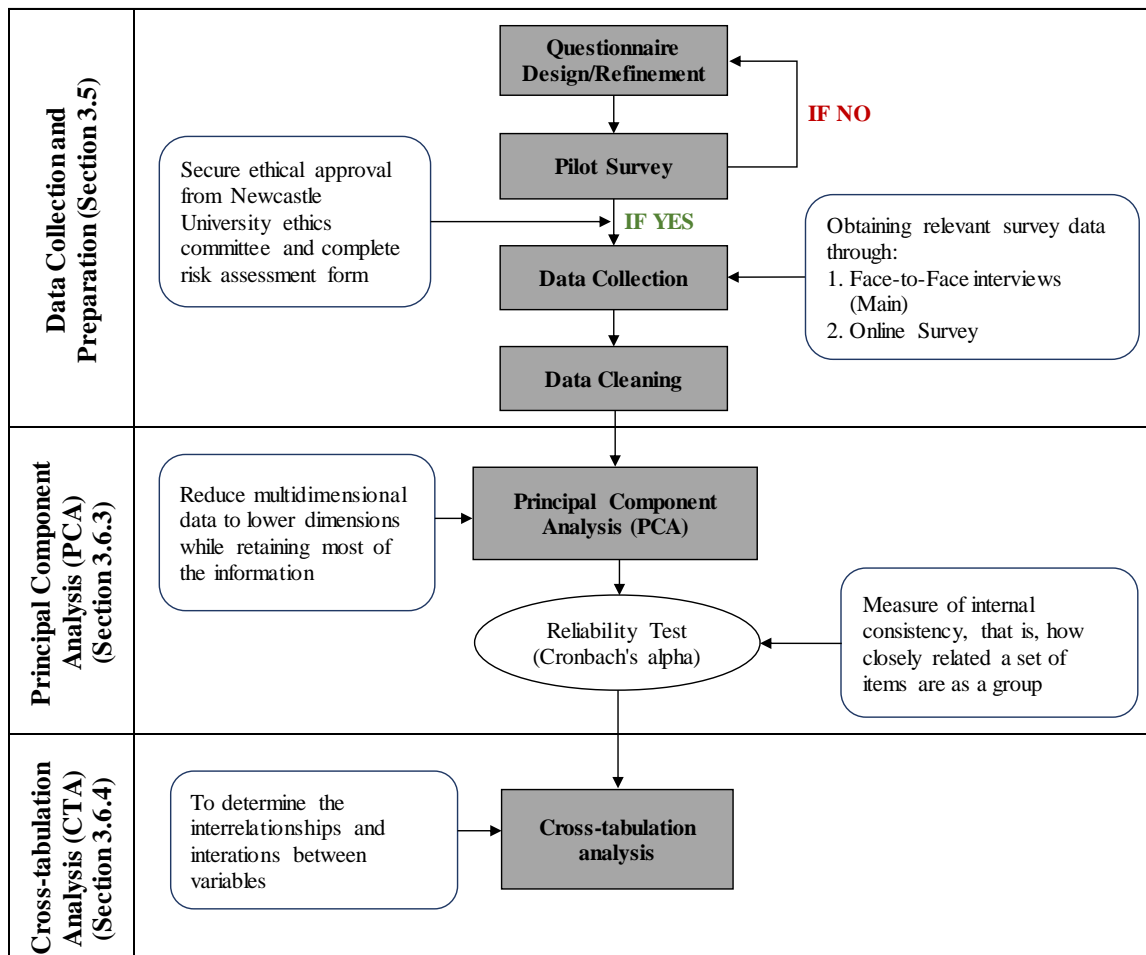


Figure 2 Methodological Framework

#### Questionnaire Design

This study is empirical in nature, involving primary data collected by means of survey using a structured questionnaire. Table 3 resents the overview of the questionnaire. The questionnaire was categorised into three sections as follows: *Section 1*: respondent's journey characteristic, *Section 2*: respondent's perception of the quality



of the Metro related infrastructure, *Section 3*: respondent's demographic details. The questionnaire design will be discussed in detail in the following sub-sections.

*Section 1 (Current Journey)*: The first section addresses journey specific characteristics including departure and arrival stations; frequency of Metro use (10 or more times per week, 5 to 9 times per week, 1 to 4 times per week, less than once a week, once per month and less than once per month); ways to purchase tickets (ticket machine at station, travel shop, from bus driver/ferry/rail, Gold Card (Concession), internet/website and other). Researchers able to categorise passengers into groups based on the data/information obtained.

*Section 2 (Perception of Service Quality)*: In the second section, passengers were required to rate their perception about importance of infrastructure, along with their respective satisfaction levels. There were fifteen pairs of importance-satisfaction statements where respondents were asked to express their opinions on a five-point Likert-type scale, in which 'one' represents very unimportant/very dissatisfied, 'three' represents neutral and 'five' represents very important/very satisfied. In addition, a text box is included at the end of this section to allow passengers providing insights on their perception of Metro related infrastructure which may not be included within the survey.

The main purpose of adopting a scale with an odd number of categories is having a mid-point which allows respondents to report neutrality. The fact that some people are legitimately neutral on a subject. Forcing respondents to choose a side on an even scale will significantly bias the end results as truly neutral people are required to select a category that does not truly represent their opinion (Stieger et al., 2007).

*Section 3 (Demographic Profile)*: The final section of the questionnaire is related to demographic profile of respondent-passengers. It is essential to include demographic questions in a survey as it enable the categorisation and measurement of customers of different gender, age group and employment status into groups based on similar characteristics for statistical research and analysis. Research in the US demonstrated that there is an important link between socio demographic characteristic and travel behaviour (Rosenbloom, 1998).

The structure of the survey designed by the researcher was based on the questionnaire guidelines proposed by Bryman (2012); for example, demographic questions should be introduced later in the survey to ensure that passengers would not feel uncomfortable from being asked for personal information, which perceived to be sensitive and difficult before the interviewers build trust or rapport with the respondents.

Table 3 Key questions of the survey

Sections	Description	Information/Data
Section 1	Journey Characteristic	Departure station
		Arrival Station
		Frequency of Use
		Ways to Purchase Tickets
Section 2	Perception of Service Quality	Importance of 15 Quality Attributes of Metro related infrastructure
		Satisfaction of 15 Quality Attributes of Metro related infrastructure
		Additional Comments (Text Box)
Section 3	Demographic Profile	Gender
		Age
		Employment Status

### Description of the Survey

Face-to-Face interviews, also known as in-depth interviews, are adopted as it is the most versatile and appropriate when aiming detailed perceptions, opinions and attitudes. The main procedure that was required prior to data collection is securing ethical approval from the university ethics committee to ensure that the dignity, rights and welfare of participants are protected. It is essential to prevent any physical and emotional hurt or issues to the participants involved throughout the study (Limb and Dwyer, 2001). At the beginning of the survey, brief introduction was provided such as the objective of the study and a statement of guarantee of confidentiality. Participants are informed that they have right to withdraw at any time without providing any reasons.

### **Pilot Survey**

According to Fowler (1995), design or structure of the questionnaire has significant impact on the survey results where it should be able to reflect the actual differences in a respondent's attitude and perceptions. Conversely, poor design of a questionnaire bias the responses resulting in misleading and erroneous information (Brace, 2008).

Pilot survey was carried out to investigate any issues and concerns related to the questionnaire structure and format, phrasing and wording grammar of the questions which allowed modification or improvements on the questionnaire latter during the refinement process. The pilot survey involved a total of 25 participants; Female (N=13) and Males (N=12). Three predefined questions were asked upon completion of the questionnaire include:

1. Did you understand the questions?
2. Did you find it easy/clear regarding the questions?
3. Any additional comment/feedback?

The time taken to complete the questionnaire was recorded which is approximately 8 minutes. Out of 25 samples, 80% of the respondents understood the questions and found the questions easy/clear. Based on the preliminary analysis, researcher has confirmed that the initial questionnaire which consist of thirty-seven questions in total were too many, which may lead to loss of interest in completing the questionnaire after some time. Hence, number of questions have been reduced to twenty-three where the time required to complete the questionnaire was reduced simultaneously.

### **Main Survey**

Convenience sampling technique was adopted for data collection as random sampling technique was not feasible (Ghosh et al., 2017). However, to overcome the shortcoming of convenience sampling that every member of population does not have equal chance of being chosen, the survey was spanned over a week at both Metro station and on-board during different times of day and night to ensure that varied types of passengers (business traveller, commuters and leisure) coming from and going to difference places could be included.

A total of 265 questionnaires were filled, of these, 65 (24.53 per cent) were excluded from the final analysis. The reasons are summarised as follows:

1. The questionnaire was incomplete as passengers had limited time to complete it fully, arrived at the destination or had urgent task to undertake so could not complete if fully.
2. Missing some important information such as failure to record the passenger's perception about importance of amenities or satisfaction levels.

## **5. ANALYSIS**

Two methods have been utilised to analyse the data so collected. Principal Component Analysis (PCA) followed by Cross-tabulation Analysis (CTA) were conducted in order to identify interrelationships that emerged from the survey data and will discussed in detail in the following sub-sections. The goal is to gain an in depth understanding of factors that are significant for satisfaction out of Metro related infrastructures, facilities and services.

### **Principal Component Analysis**

To investigate the relationships among the variables and to gain exposure on the data structure, a dimension reduction process was introduced. A Principal Component Analysis (PCA) was chosen to reduce number of random variables to smaller number of principal components that will account for the correlations, to get an underlying concept and to facilitate interpretations (McDonald, 1985).

Kaiser's criterion can be used to determine the number of factors to retain. The criterion recommends retaining all factors which are above the eigenvalue of one. Furthermore, the Scree test, involves in examining the graph of eigenvalues where the number of factors to be retained is data points that are above the 'break' (Cattell, 1978). The test of validity of data for PCA has been investigated using Kaiser-Meyer-Ohlin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO ranges from 0-1 where the acceptable level for KMO test is 0.60 and above as shown in Table 4. Bartlett's Test of Sphericity relates to the significance of the study. A probability of less than five per cent is desirable, following which, Cronbach's alpha is calculated.



Table 4 KMO/MSA value index (Source: Sarstedt and Mooi, 2014)

KMO/MSA Value	Adequacy of the correlations
Below 0.5	Unacceptable
0.50-0.59	Miserable
0.60-0.69	Mediocre
0.70-0.79	Middling
0.80-0.89	Meritorious
0.90 and higher	Marvellous

Cronbach's alpha is an estimate of the internal consistency associate with the scores that can be derived from the scales or composite scores. Reliability of the data is essential to identify validity associated with the scores or scales. For example, if the number of significant factors is six then run Cronbach's alpha test for each factor accordingly. Cronbach's alpha coefficient values greater than 0.7 is desirable (Ramayah, 2011). Table X presents the output from the principal component analysis of those variable measuring respondents' perception regarding Metro related infrastructures, facilities and services.

Referring to the results, the KMO was turned out as 0.825, which falls within a good range, demonstrating adequacy of the correlations. In addition, the Bartlett's test of Sphericity was statistically significant with  $p=0.000$  which is smaller than five per cent, indicating the correlations between items available in the data set were sufficient.

Three significant factors that have been identified to represent passenger's perception towards satisfaction of Metro related infrastructures: "Safety, Security and Comfort", "Infrastructure Quality" and "Ticket Purchase Facilities". Factor 1 (Safety, Security and Comfort) includes seven statements which are personal security on trains, personal security at stations, graffiti and damage, availability of seats, amount of standing room, lighting at the stations and cleanliness inside train. Four main factors together explain Factor 2 (Infrastructure Quality); they include cleanliness for both Metro stations and trains as well as the appearance, quality or working order of station related aspects. Factor 3 (Ticket Purchase Facilities) is composed of two statements regarding the ticket machines such as the usefulness and availability of information. Cronbach's alpha has been calculated for each factor determined in the analysis to identify the internal consistency of the grouped variables. The Cronbach's alpha values for factor 1, 2 and 3 are 0.844, 0.754 and 0.864 respectively, all falling above the minimum acceptable level of 0.7, indicating a high level of reliability. Table 5 presents the output from the PCA of those variables measuring passenger's perception about the Metro related infrastructures.

Table 5 Output from the Principal Component Analysis – Metro Related Infrastructures

Statement	SD	M	FL
<b>Factor 1 Security, Safety &amp; Comfort (<math>\alpha: 0.844</math>)</b>			
Your personal security on trains	0.821	4.50	0.848
Your personal security at stations	0.85	4.48	0.848
Cleanliness inside train	0.946	4.16	0.675
Graffiti and damage	1.037	3.60	0.596
Availability of seats	0.982	3.53	0.558
Lighting at stations	0.99	4.01	0.526
Amount of standing room	0.865	3.84	0.404
<b>Factor 2 Infrastructure Quality (<math>\alpha: 0.754</math>)</b>			
Condition of station	0.888	3.97	0.856
General cleanliness of station	0.893	3.96	0.819
Cleanliness outside train	0.992	3.46	0.577
Condition of escalators	1.078	3.79	0.494
<b>Factor 3 Ticket Purchase Facilities (<math>\alpha: 0.864</math>)</b>			
Facilities for buying tickets	1.118	3.97	0.898
The information on ticket machine	1.113	3.76	0.896
<b>KMO: 0.825</b>			
<b>Bartlett's Test of Sphericity: 0.000</b>			

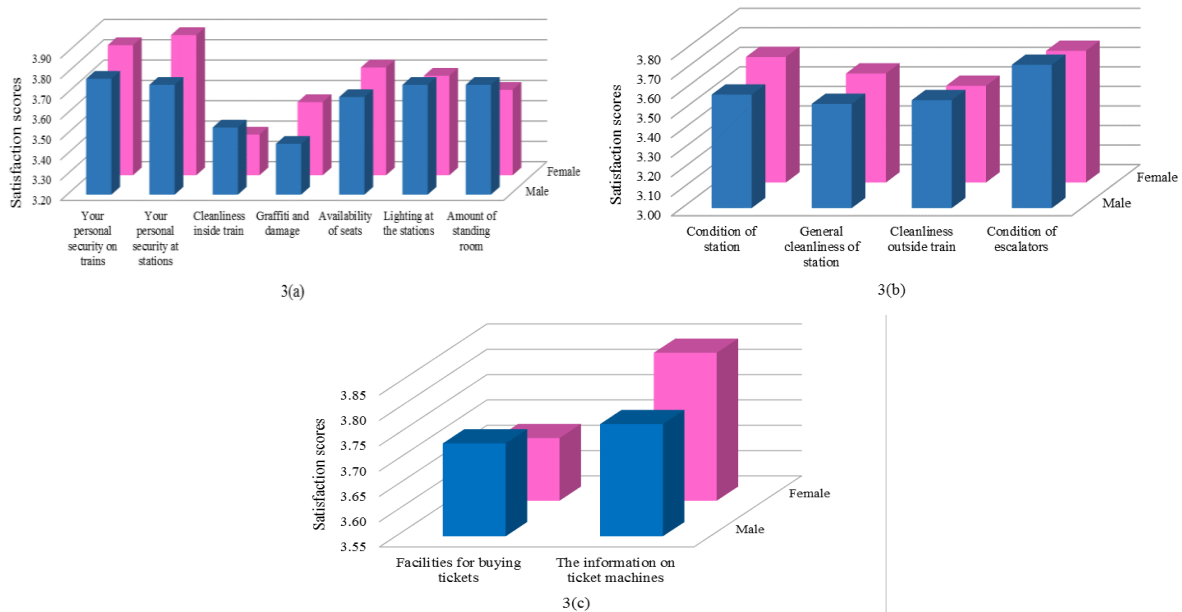
Notes:

KMO: Kaiser-Meyer-Olkin;  $\alpha$ : Cronbach's alpha; SD: standard deviation; M: mean; FL: factor loading

### Cross-tabulation Analysis

Cross-tabulation analysis, also known as contingency table analysis, is adequate and appropriate when investigating relationships within a dataset that may not be clear during the process of examining total survey responses. It also provides a way of examining and comparing the outcomes for one or more variables with the outcome of another variable(s) (Douglass et al., 2018). The purpose of using the cross-tabulation analysis in this study was to investigate the relationship between satisfaction scores and demographic profiles:

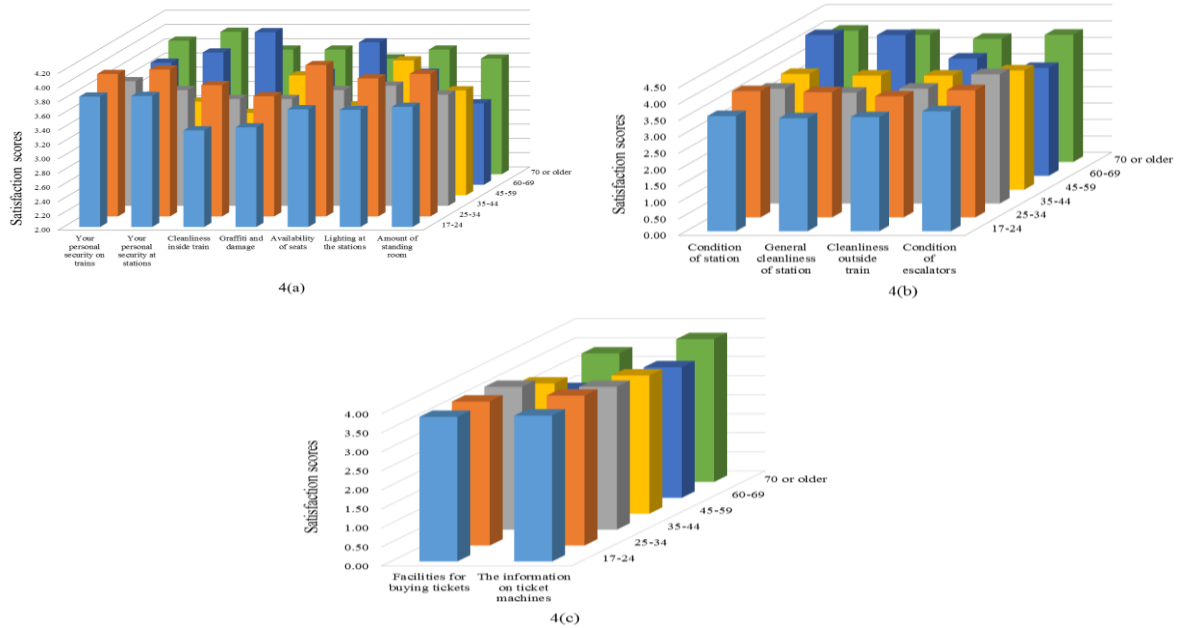
1. Gender
2. Age
3. Professional/Employment Status
4. Frequency of Use



**FIGURE 3 Satisfaction scores with respect to attribute in Factor 1, 2 and 3, and Gender.**

- (a) Satisfaction scores with respect to attribute in Factor 1 and Gender
- (b) Satisfaction scores with respect to attribute in Factor 2 and Gender
- (c) Satisfaction scores with respect to attribute in Factor 3 and Gender

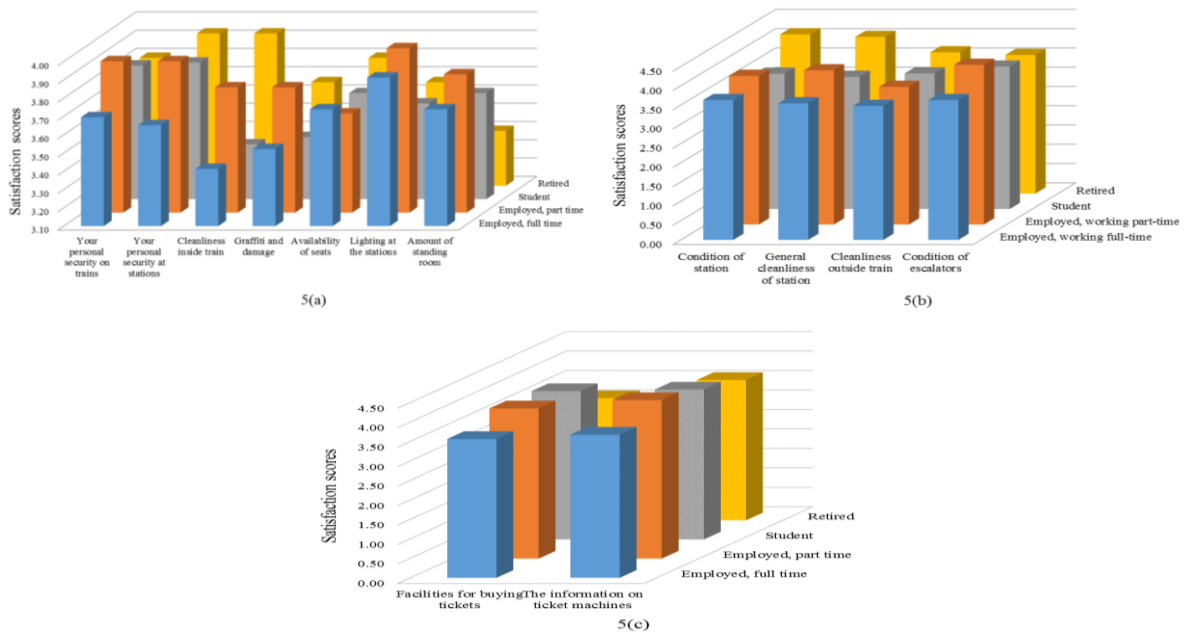
Gender-wise the respondent-mix is fairly balanced, with female contributing to 47.5% of the sample while male contributing to 52.5% of the sample. Figure 3 indicated that there were significant differences between male and female in evaluating security measures at both the Metro stations and trains. This is consistent with the findings of Khalil and Karam (2015) that female population is feeling more at risk than that of male population. Lynch and Atkins (1988) have assessed that female population are more worried about their personal safety as compared to male population. The two attributes related to cleanliness, namely, *cleanliness inside train* and *graffiti and damage* received average scores of less than 3.60 which is slightly lower as compared to other attributes. As regards to the information on ticket machines, the satisfaction scores as per female ratings were seen to significantly higher than that of male ratings. In fact, the difference of satisfaction scores between female and male respondents was only 0.17. Figure 3b and Figure 3c show similar trend between female and male respondents.



**FIGURE 4** Satisfaction scores with respect to attribute in Factor 1, 2 and 3, and Age Group.

- (a) Satisfaction scores with respect to attribute in Factor 1 and Age Group
- (b) Satisfaction scores with respect to attribute in Factor 2 and Age Group
- (c) Satisfaction scores with respect to attribute in Factor 3 and Age Group

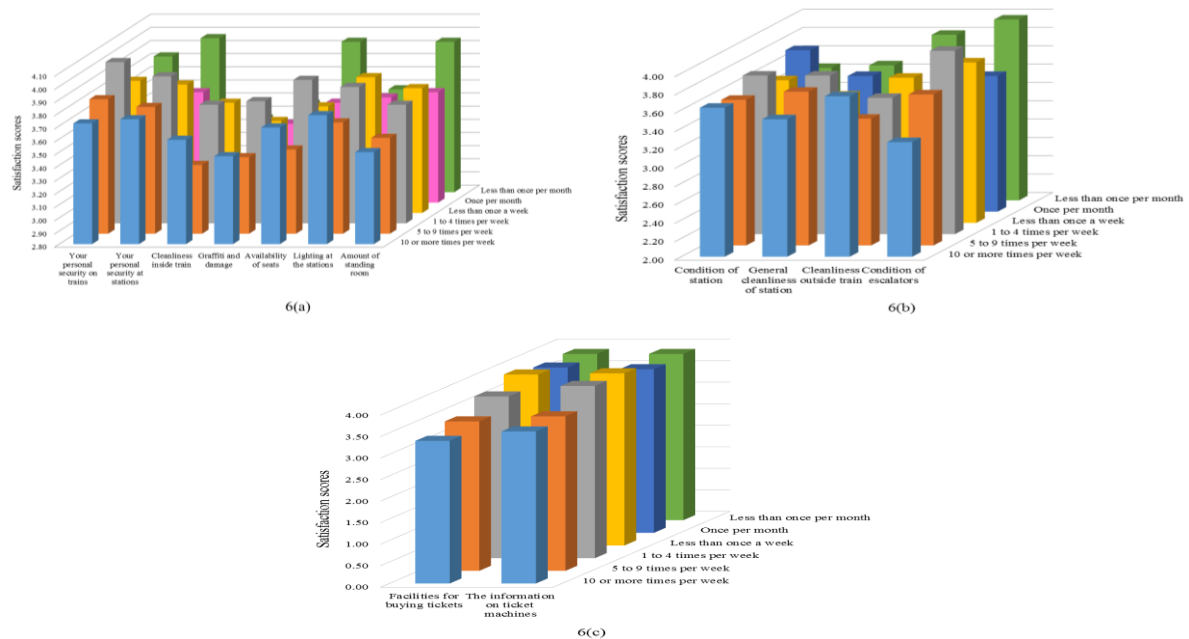
Most of the respondents are in the age group of 17-24 years, followed by those in the category 25-34 years. The structure of the age groups will include a mix of students, professionals and retirees. In general, results across three factors show similar trend of which lower satisfaction when age decreases. Advent of information technology and smartphones penetration are most likely the reason behind this surprising outcome. In 2017, 96 per cent of the respondents aged under twenty-five reported owning a smartphone (Statista, 2017) which often lead to distractions. Smartphone users often play on the devices rather than paying attention to the surroundings (Cornell, 2011). Plus, majority of respondents in the age group of 17-24 years are students, where frequency of use of metro is relatively low thereby perceived importance and expectation of Metro services are less significant. Again, the results identified that the satisfaction scores for both the attributes *cleanliness inside trains* and *graffiti and damage* are lower as compared to others. These attributes were seen to significantly influence satisfaction. Another facet that is insignificant from perspective of passengers is *availability of seats*. However, the Metro carriages look set to get London Underground-style seating, also known as linear seating, launched after year 2021 (Dickinson, 2017). Lastly, the results from Factor 3 suggested there is a good provision for both *facilities for buying tickets* and the *information on ticket machines*.



**FIGURE 5 Satisfaction scores with respect to attribute in Factor 1, 2 and 3, and Professional/Employment Status.**

- (a) Satisfaction scores with respect to attribute in Factor 1 and Professional/Employment Status
- (b) Satisfaction scores with respect to attribute in Factor 2 and Professional/Employment Status
- (c) Satisfaction scores with respect to attribute in Factor 3 and Professional/Employment Status

Most of the respondents were students (61.5%) have comparatively large presence, followed by full-time workers (23.5%), retirees (8%) and part-time workers (7%). An important conclusion that may be drawn is that the two attributes related to cleanliness, namely, *cleanliness inside* trains and *graffiti and damage* again received lower ratings compared to other attributes thereby needed improvements. The satisfaction scores as per full-time workers and student's ratings are less than other types of travellers. The reason behind this could be the fact that they were focused on their job and work which lead to less aware of the surroundings. For comfort aspect such as *amount of standing room* retirees tended to give lower ratings than the other types of travellers. There is no significance difference between the groups for the ratings for Factor 2 (Infrastructure Quality) except for *condition of station* and *general cleanliness of station* where the retirees gave higher ratings than the other groups. *Facilities for buying tickets* may be insignificant from retirees' perspective. One reason behind this could be the fact that majority of them had season ticket while some of them tended to purchase tickets from the travel shops.



**FIGURE 6** Satisfaction scores with respect to attribute in Factor 1, 2 and 3, and Frequency of Use.

- (a) Satisfaction scores with respect to attribute in Factor 1 and Frequency of Use
- (b) Satisfaction scores with respect to attribute in Factor 2 and Frequency of Use
- (c) Satisfaction scores with respect to attribute in Factor 3 and Frequency of Use

A great majority (33%) of the respondents use TW-Metro more than 5 times per week, followed by those who use 1 to 4 times per week. Unsurprisingly, both the *cleanliness inside trains* and *graffiti and damage* received low ratings than other attributes. However, regular travellers of 5 to 9 times per week tended to give lower ratings compared to others. For security aspects such as *personal security on trains* and *personal security at stations* occasional travellers travelling less than once per month gave higher scores than other travellers. Comfort-wise such as availability of seats, regular travellers of 5 to 9 times per week tended to give lower ratings than the other type of travellers. Regular travellers of 10 or more times per week gave the lowest rating for condition of escalators. A similar trend is observed regarding the *facilities for buying tickets* and *the information on ticket machines* such that satisfaction scores decreases as frequency of use increases. In general, passengers travelling more frequently express a lower of satisfaction than those travelling less frequently. This indicates that the level of satisfaction of less frequent travellers is defined by their journey purpose rather than their frequency of travel.

## 6. CONCLUSIONS AND RECOMMENDATIONS

Findings of the study highlight the actual condition of both Metro stations and trains, and the importance-satisfaction paradigm concerning Metro related infrastructures, facilities and services, drawn based on Tyne and Wear Metro user responses. Two analytical approaches were utilised to achieve the aim and objectives: Principal Component Analysis (PCA) and Cross-tabulation Analysis (CTA).

Principal Component Analysis (PCA) has confirmed three significant factors, namely, “Security, Safety and Comfort”, “Infrastructure Quality” and “Ticket Purchase Facilities”. Assuredly, passengers would be satisfied provided that the attributes tagged under these significant factors perform as per expectations. These outcomes are consistent with past studies that have identified cleanliness (Drea and Hanna, 2010) and safety and security (Atkins, 1990; Cavana et al., 2007) were significantly in influencing satisfaction.

Results of Cross-tabulation Analysis (CTA) direct the researchers to conclude that there is a significant difference between satisfaction scores and demographic profiles as well as basic amenities including *cleanliness inside train*, *graffiti and damage*, *your personal security on trains*, *your personal security at stations* and *lighting at the stations* have performed well below expectations, thereby leading to dissatisfaction. Hence, improvement in these areas are essential for the transit agencies to provide better services to the passengers.

Application of these methods are not limited to Tyne and Wear Metro only. It may be utilised for assessing public services where the users are varied and attributes can be clearly defined. These evaluation methods help the transit agencies (NEXUS PTE) to prepare investment plans to achieve higher user's satisfaction.

In general, satisfaction levels vary between the cultural and socio-economic background of the respondents. Therefore, results obtained for Tyne and Wear Metro may not be representative for case studies drawn from other parts of the world as the respondents' cultural and socio-economic background differ greatly from that in United Kingdom. However, the statistical methods presented in this study remain applicable.

The most notable limitation of this study was the sample size; a greater sample size would likely mean more findings could be drawn. This is because a larger sample size may generate results that are different, although more representative, compared with what was obtained. This study's questionnaire was administered in a group of 5 but in the future web-based means may be undertaken to reduce both the time and cost associated with Face-to-Face interviews.

This study is limited to the subject evaluation of Metro related infrastructures, facilities and services. Parameters related to delays and technical, managerial or behavioural issues have not been considered, although they are likely contributing factors to individual satisfaction therefore may be included for further research. On top of that, parameters such as *ticket price – value for money* have been taken into account in international context by several authors (Cervero and Wachs, 1982; TriMet, 1995; Eboli and Mazzulla, 2009a,b) as significant predictors of satisfaction have not been included.

Lastly, a detailed survey is proposed to provide respondents the opportunity to specifically identify areas they wish to see improvements; this will contribute to the development of new proposals and the evaluation of their impacts on future customer services.

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