An Analysis of Lahore Metrobus Service

A thesis submitted in partial fulfillment of

the requirements for the degree of

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in

Transportation Engineering

Submitted By

Muhammad Umair Ali

(NUST– 2013 – 62117 – MSCEE –15113–F)

National Institute of Transportation – (NIT)

School of Civil & Environmental Engineering (SCEE)

National University of Sciences and Technology (NUST)

Sector H-12, Islamabad, Pakistan

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This is to certify that the contents and form of

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Muhammad Umair Ali

(NUST-2013-62117-MSCEE-15113-F**)**

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_____

(Associate Professor)
Dr. Anwaar Ahmed, Ph.D.
Research Supervisor,

National Institute of Transportation (NIT),
School of Civil and Environmental Engineering (SCEE),
National University of Sciences and Technology (NUST), Islamabad.

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Dedicated To

My Beloved Spiritual Guider, My Advisor, My Parents, My Wife, My Son and Family members

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(Muhammad Umair Ali)

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LIST OF ACRONYMS

BRTS	Bus Rapid Transit System
MBS	Metro Bus System
JICA	Japan International Co-Operation Agency
MB	Metro bus
GDP	Gross Domestic Product
PPP	Purchasing Power Parity
R.O.W	Right of Way
LOS	Level of Service
ITS	Intelligent Transportation System
CBD	Central Business District
AVL	Automatic Vehicle Location
Pphpd	Passengers per hour per direction
TSP	Transit Signal Prioritization

ABSTRACT

Pakistan has experienced a rapid motorization in last few decades as motorized vehicle population increased from about 5.3 million in year 2002 to 11 million vehicles of all type in year 2012. Also, the large scale migration of people into cities has resulted into urban sprawl and is incurring huge social cost in term of traffic congestion and higher housing prices. Aging transportation infrastructure of cities like Lahore is unable to meet the enhanced traffic demand due to increased motorization. A well-planned, efficient and sustainable urban transportation system is necessary to meet enhanced travel demand in major cities of Pakistan.

In present study, an effort has been made to access the service quality provided by the Lahore Metrobus which starting operations in March 2013. Present study developed an enhanced framework to carry out a detailed analysis of commuter satisfaction and quality of service provided by the Lahore Metrobus. Study used both subjective and well as objective scenarios to assimilate commuter satisfaction with existing quality of service of Lahore Metrobus. A comprehensive questionnaire was used to collect data on commuters socio-economic characteristics (gender, age, auto ownership, income level, profession, and number of individuals with a valid driving license in the family), traveling trends (travelling mode, daily commute timings, average distance travelled to get to public transport prior to Metrobus operations, present distance travelled to get the Metrobus, mode to get Metrobus, if longer distances are involved, purpose of commuting by Metrobus, average daily distance travelled by Metrobus, average number of weekly trips in Metrobus and commuter rating of overall level of satisfaction with Metrobus (extremely satisfied, satisfied, neutral, unsatisfied and extremely unsatisfied). A total of 400 valid responses collected at all (27) stops of Lahore Metrobus were used for present study. Due to the ordinal nature of the response variable (overall level of satisfaction of commuter with Lahore Metrobus) an ordered probit model has been estimated to study the association of overall level of satisfaction of commuter with Lahore Metrobus with different explanatory variables. Model results revealed that male commuters, commuters from a family size of more than five members, commuters with an average commute time of over 25 minutes before start of Lahore Metrobus and commuters with higher

perception of Lahore Metrobus customer service and frequency are more likely have higher satisfaction of overall level of service provided by Lahore Metrobus. Study results also revealed that a commuter belonging to a family with more number of individuals having valid driving licenses (a proxy for higher income and education) is less likely to have higher satisfaction of overall level of service provided by Lahore Metrobus, and more likely have lower satisfaction of overall level of service provided by Lahore Metrobus. Marginal effects are computed to see the impact of six significant variables on the intermediate categories of the commuters overall level of satisfaction with Lahore Metrobus.

In second part of present study, service performance evaluation of Lahore Metrobus was carried out in terms of established public transit criteria for the level of service. Quantitative and qualitative data were collected from field and values obtained were compared with recommended standards given by Transit Cooperation Research Program of USA. Seven service performance measure (quality attributes) that were considered in present study include: (1) reliability (2) assurance (3) comfort (4) responsiveness (5) availability (6) convenience and (7) accessibility. The field data for seven quality attributes (such as headway, frequency, physical amenities and travel speed) were collected from different bus stations and the collected information was then compared with the recommended level of service given in the literature for each indicator or by comparing it with the conventional public bus system attributes or agency standards. The overall service performance was then compared with the commuter satisfaction survey to seek the differences between the commuters expectation and the agency overall service performance. The study results revealed that Lahore Metrobus is providing reasonable level of service to the commuters that meet commuters' expectation and recommended standards given by Transit Cooperation Research Program of USA. The seven quality attributes i-e reliability, assurance, comfort, responsiveness, availability, convenience and accessibility are found to be equally satisfied from commuters' point of view and agency provided standards. The results of the present study are expected to help transit agencies, policy makers and planners to improve the Metrobus services in different cities of Pakistan.

CHAPTER 1

INTRODUCTION

1.1 Background

Over the years, cheaper automobile financing schemes and huge economic development boost the transport industry in Pakistan. The thriving of automobile ownership, congested the roads of metropolitan cities like Lahore, Karachi and Peshawar etc. Squeezing of the road width by overcrowding enforced the transport planner to develop transport infrastructure in mega cities of Pakistan. The back bone for every developing country demand a well-established transport infrastructure. The demanding capacity and adjusting the maximum vehicles on road in the urban has become a challenging task for the transport planner. Increasing quantum of automobiles on restricted road way, pollutants the cities by worsening the quality of life. Construction of Underpasses, flyovers and stretching the road way width causing financial stress to the Govt. of Pakistan. Polluted metropolitan, congested roads and huge capital construction cost lead the transport planner to viable urban public transport.

Tremendous rush in the automobile industry augmented travelling time, dramatic congestion, uncomfortableness and security trepidations in the metropolitan cities of Pakistan. Successful urban public transport integrate the key parameters to attract the commuters. Safe, convenient, comfortable, efficient, economic and quality bus service plays vibrant role to reduce congestion and huge construction cost. Generally, conventional public bus system is slower, uncomfortable, awkward, unpredictable and unreliable and this inferiority in public bus service quality has shifted the commuter to private vehicles. As a result, congested roads and demanding automobile ownership in urban restrict the improvement of the conventional public bus system.

Remarkable operational success in the urban transit system can only be achieved by designing it to optimal and providing all the services aspects that meet operators/agency and commuters expectation. Proper planning, decides the cost of

the Urban Transit System and it should be comfortable, reliable, safe, and minimal out of vehicle and in vehicle time from origin to destination with minimal environmental impacts.

Pilot project started in 1974 Curitiba (Brazil), Bus Rapid Transit System (BRTS) today has turn out to be aspiring outcrops for the world. Till year 2000, BRTS projections inspired USA and Columbia leading the successful project of Trans Milenio in Bagota. Around 146 BRTS projects are reported till date ((Global BRT Data, 2012; Levinson et al., 2003; Ernst, 2005; Wright, 2005). Busway of Trans Jakarta instigated in 2004, was a conspicuous project for Asian Countries. Later, Seoul's and Beijing started the BRTS in 2004. Hangzhou (China) opened his first BRTS project in 2006. India and Pakistan welcome the BRTS and initiate it in mega cities in the last decade.

BRTS is one of the emerging system all over the world especially in Asia since 2004. Capacity and speed on the urban roads can be enhanced by providing a system that has separate bus lane. Improved living standard over the years has diverted the attention of transport planner to provide a viable public transport to the common citizen. To accommodate the densified traffic over the streets and to improve local public transport in the metropolitan cities was an immense contest for the transport planner. In view of the above, transport planner introduced a new standardized public transport in Pakistan called Metrobus/Bus Rapid Transit System (BRTS). In 2012, Govt. of Pakistan built a pilot project of BRTS or Metrobus in Lahore. The construction of Metrobus Project in Lahore was a new horizon to the policy maker. In the last five years, Pakistan has launched Metrobus in mega cities like Islamabad, Rawalpindi and Multan.

In Lahore, Islamabad-Rawalpindi and Multan Metrobus is isolated from the mixed traffic. At grade and bridge running way is constructed for the Metrobus. The bus stations are used exclusively for Metrobus providing interchange facility at each station. Punjab Masstransit Authority (PMA) head office in Lahore, is operating all the Metrobus in Punjab. The main objective of the system is to reduce congestion problem, environmental degradation, overall capital cost and attract

more commuters by providing reliable, comfort, economic, and attractive, efficient, convenient and rapid public transport fulfilling the commuter needs.

Service quality, one of the emerging field in academic, public and private sectors has shifted the trend to customer oriented service and quality enhancement. The most highlighted aspect in public transport sector is its service quality. Huge investment in the public transport sector requires service quality analysis in terms of commuter or bus commuter satisfaction for future extension. The improved service quality in public transport will attract more commuter and cut off the automobile users on road.

1.2 Problem Statement

Karachi, Lahore, Peshawar, Quetta and Islamabad are metropolitan cities of Pakistan. The provincial city Lahore is hub and heart of Punjab. Over the last 15 years, travel demand for the city has boosted to 13.6 Million trips per day with a population of approximately 10 million in the year 2006 reported by the Japan International Cooperation Agency (JICA) and an automobile registration has increased to 10-15 percent per annum for the city Lahore.

Immense traffic congestion and dramatic lift in vehicle registration for the city of Lahore with annual economic growth of 5 percent demanded modern public transport. Japan International Cooperation Agency (JICA) prepared master plan for Lahore city to overcome traffic problems and the detailed study on the transportation network of Lahore revealed two corridor for the public transport system.

a. Ferozepur Road Corridor 28.7 km
b. Multan Road Corridor 12.4 km

In the Year 2013, Lahore Metrobus was introduced for the Ferozepur Corridor having length of almost 27 km. Operational success of Metrobus Lahore, diverted the attention of transport planner to provide a sustainable public transport and later Metrobus was provided in Islamabad-Rawalpindi and Multan along the main corridor to mitigate congestion problems.

The prime objective to provide Metrobus was to minimize the use of automobile by attracting more commuters. Prior to provide new Metrobus in the country, there is a need to investigate commuter satisfaction in term of service quality. Introducing new policy measure to improve quality of the Metrobus can attract more commuters to the system and continuous improvement in the public transport sector can only be achieved by considering commuter perception.

This is the first research effort at national level to analysis and to evaluate the performance of Metrobus in view of the commuters.

1.3 Research Objectives

To evaluate the service quality of newly introduced public transport facility is core theme of the research. In view of the above, enlisted objectives are as followed

- To assess the commuter satisfaction with the overall quality of service provided by Lahore Metrobus service.
- To carry out service performance evaluation of Lahore Metrobus Service.

1.4 Overview of Study Approach

A sequential procedure leading the following tasks is set to overlook the research objectives.

- Extensive literature review drove through the introduction of the BRTS and public transport service quality concept.
- Setting up the frame work to achieve the subjective and objective evaluation of Lahore Metrobus.
- Collation of primary data through commuter questionnaire and site investigation.
- Investigating the significant relationship between demographic variables, commuter travel characteristics and quality indicators factors in response to commuter satisfaction.
- Conclusion and recommendations

1.5 Thesis Organization

This thesis is organize into five chapters. Innovative history of BRTS and key to assess the commuter satisfaction with the level of service provided by the Lahore Metrobus is discussed in chapter 1. BRTS characteristics and Service Quality attributes are discussed in chapter 2. In chapter 3, research methodology to complete the task is discussed in detail and collection and collation of data is also presented in the chapter. Results from the statistical analysis, field data analysis and model estimation are discussed in chapter 4. Conclusions and recommendations are presented in chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 What is Bus Rapid Transit System (BRTS)?

Bus Rapid Transit System (BRTS) is described as "an integrated system of facilities, services, and amenities that collectively improve the speed, reliability, and identity of bus transit" (Levinson et al., 2003). It is an assimilated system with good quality buses, distinct infrastructure, and limited mix traffic running way and designed for greater speed, reliability and safety (Rehman et al., 2013). BRTS has separate bus lane and limited large spacing stops compared to local bus. BRTS is provided as it has high speed, more capacity, increased reliability and successful attraction of ridership and have environmental, social and economic benefits (Rehman et al., 2013).

2.2 Key Features of Bus Rapid Transit System (BRTS)

BRTS, a unique modern standardized public transit service comprising innumerable amenities, technologies and facilities to provide a quality public bus service has the forthcoming key elements. For valuable results better understanding of the key characteristics of concerns is essential, which are:

- Bus Rapid Transit System (BRTS) Running Ways/Guide Ways
- Bus Rapid Transit System (BRTS) Vehicles
- Bus Rapid Transit System (BRTS) Bus Stations
- Bus Rapid Transit System (BRTS) Fare Collection system
- Bus Rapid Transit System (BRTS) Operations control System
- Bus Rapid Transit System (BRTS) Passenger Information system

2.2.1 Bus Rapid Transit System (BRTS) Running Ways/Guide Ways

The key feature and major infrastructural element of BRTS is running way/guide way (Levinson et al., 2003a). Dependency of rapidness and reliability of BRTS on running way, highlighted its importance while an exclusive running way

provides higher speed, reduce delays and improve reliability (Xiyuan, 2014). BRTS running way has three general classification sort from mix traffic way to grade separated busway named as on-street, on-freeway and off-street (Xu and Zheng, 2012). First two types of running way comprises mixed traffic lanes, curb bus lanes, median bus lanes and bus only streets (Rehman et al., 2013). The on-street and on-freeway running ways save the construction cost and mixed traffic lanes are mostly induced in the areas having geometric restrictions, higher right of way cost, environmental as well as investment restraint. This type of running ways require less construction exertions but lowest operational speed and reliability (Rehman et al., 2013).

Curb bus lanes running ways are mostly introduced in the central business districts area giving higher right of way all the day and operational marking and signage reduced the huge investment and highlighted its identity (Rehman et al., 2013). Curb bus lanes running ways interfere with the traffic at intersections with high priority to BRTS (Xiyuan, 2014). These running ways simplify commuter access (Rehman et al., 2013). The running ways that have more right of way at the center of roadway with the bus stations at center or on side are categorized as median bus lanes running ways and a little capital cost is required for these running ways as only separator/delineator are required for the existing median. The painted lines and rumble strips etc. enlighten median bus lanes running ways identity (Rehman et al., 2013). The roadway width in the populated area restricts its operation (Xiyuan, 2014). The bus only streets or on-freeway running ways are constructed in the new underdeveloped area. These running ways separate the BRTS from the mixed traffic by giving it identity and improve system efficiency and these guide ways facilitate the commuter (Xiyuan, 2014).

Off-street running ways induced exclusive busway for the BRTS either in the form of elevated busway, freeways or bus tunnel and providing separate busway for the BRTS splash its identity. These running ways require huge capital investment, more construction energies and proper signal phasing to eliminate the crossroads traffic problems by giving priority to BRTS (Rehman et al., 2013). This arrangement of running way is mostly adopted in Pakistan. Bus running ways

are backbone for the speedy bus, punctuality and reliability (Xiyuan, 2014). It is recommended to provide mixed bus lanes or cub bus lanes in the denser area and bus only streets or on-freeways can be built where enough R.O.W exist (Xiyuan, 2014). Once the off-street infrastructure built up, it can be promote to rail transit (Rehman et al., 2013).

2.2.2 Bus Rapid Transit System (BRTS) Vehicles

Vehicle is another prime element of the BRTS. BRTS vehicles are better than the local vehicles and these rubber-tired vehicles, equipped with modern technology provide riding comfort and ease of boarding, larger commuter capacity, more speed and unique identity is also associated with these vehicles (Xiyuan, 2014). Provision of distinct color scheme, multiple boarding doors and low boarding floor attracts the commuter by promoting BRTS brand and its identity. Similarly internal environment, air conditioning, provision of seats, wide chassis, panoramic windows, wide walkway and ample foot space impacts the commuter perception for BRTS while vehicle operational and maintenance costs are the main expenditure of BRTS and these expenditure can be minimize by providing energy efficient vehicles such as electro-hybrid, gas fueled and low emission vehicles to protect environment (Xiyuan, 2014).

2.2.3 Bus Rapid Transit System (BRTS) Bus Stations

Commuter comfort, access, convenient and safety is associated with the BRTS stations and these are designed to enlighten the BRTS brand (Xiyuan, 2014). The connected medium between vehicle and commuter is BRTS station and the length and width of station, platform height, and location of station, fare collection procedure, real time bus information, security arrangement and basic commuter amenities/facilities are main features of BRTS station. These features, discussed above vary from one BRTS to another BRTS (Rehman et al., 2013). Comfortable waiting area, seat provision and all time weather stations distinguish BRTS station from conventional bus station and BRTS station should be designed at its optimum that the standard bus stations with barrier free amenities for all group ages (Rehman et al., 2013).

2.2.4 Bus Rapid Transit System (BRTS) Fare Collection System

The impressive component of BRTS to commuter is its fare collection system and it directly relate with system benefits and cost. Fast and convenient fare collection system reduce boarding time, dowel time, bus operating cost and generate more revenue by attract more commuters (Rehman et al., 2013).

There are diverse fare collection system i-e on-board, off-board, payment by cash, prepaid tickets, passes, magnetic strip or smart card. The most cost effective, efficient, saving dowel time by all doors boarding and convenient to commuter is off-board fare collection system (Levinson et al., 2002; Goodman et al., 2005; Tirachini and Hensher, 2011). On-board and smart card technology fare collection system can also be another good option. Advance technology fare collection system integrated with AVL data improves BRTS efficiency, ridership, real time commuter travel information and operational system (Rehman et al., 2013).

2.2.5 Bus Rapid Transit System (BRTS) Operations Control System

Induction of modern technology to a system provide better control over the system (Rehman et al., 2013). In view of above, BRTS can be better controlled by Intelligent Transportation System (ITS) and the operational success of BRTS depends on its better control (Xiyuan, 2014). One of the key element of ITS application is automatic vehicle location (AVL) system giving better control and real time bus information for bus schedule. Similarly use of other application such as specialized bus signals, automatic signal activation sensor and transit signal prioritization (TSP) at intersections reduce waiting time at intersection, improve running speed and enhance system performance (Rehman et al., 2013).

2.2.6 Bus Rapid Transit System (BRTS) Passenger Information System

To make system more friendly and attractive to commuter and riders perception to the service quality required effective, exact and reachable commuter information technologies (Rahman et al., 2012b). To get route guidance and bus

schedule prior to start a trip is required by the commuter and the prime source of the information may be telephone or internet (Rahman et al., 2013). Real time bus information including bus arrival time, next bus station distance, name of current station, next station arrival time, location information, service alerts and interchange facilities information are required to improve the BRTS ridership by reducing waiting time fears (Rahman et al., 2013).

All above stated features of BRTS assimilated to form a system, state as BRTS (Rahman et al., 2013). The layout features, design characteristics, operational techniques and all features of BRTS may vary from system to system depending upon land use pattern, investment plan, and environmental consideration. It may be possible that two BRTS in the same city may have different integrated systems (FTA, 2004).

2.3 Why Bus Rapid Transit System (BRTS) is Preferable

The supremacy of BRTS over conventional bus system can be sketched by the upcoming enormous advantages (Rahman et al., 2013; Xiyuan, 2014)

a. BRTS provides speedy and trustworthy public bus system.
b. Large capacity of the BRTS is an advantage over the conventional bus system.
c. The signal preference, dedicated running way and isolated bus station of BRTS enhance the running speed.
d. Reduction in accident improve the commuter security perception.
e. Short waiting time, limited boarding time, automated fare collection system and introduction of ITS application play vital role to save commuter excursion time.
f. The use of modern technology enable to carter the frequency for undivided commuter demand (for peak hour and off peak hours).
g. This is cost effective system in term of construction cost and operation cost.
h. BRTS provides propitious flexibility for construction time and operational period.
i. BRTS reduced environmental impacts on human health.

j. Articulated buses has boost the commuter comfort level and integrated system has increased accessibility perception.

2.4 Lahore Metrobus

Capital city of Punjab is Lahore. It is the biggest urban city of Punjab and second largest city of Pakistan after Karachi. It is located near Indian border named Wagah in north-west of district Sheikhupura. The city Lahore is known by its ancient Punjabi cultural and historical places. It is the central business hub of the Province Punjab with an estimated GDP of 58.14 billion (PPP) in the year 2014 as per Lahore fact sheet developed in 2016. At the time of Independence, motorized trip was limited due to easy access to home, workplace and shopping places and the mode of travel was walking or Tonga (Qadeer, 1998). In 1947, the main travelling source for intercity journey was the rail (Hassan, 1998). To provide intercity transport for cities at lower cost with adequate efficiency, Road Transport Board was recognized in 1951. Till 1960, more investment was done in the railway sector with the ratio 30 to 70 to road and railway (Imran, 2009). The era of transport sector starts after the second five year plan of Pakistan (1960-1965) in which more attention was given to the road sector instead of rail sector.

The increasing population and development in the road infrastructure demanded increased public transport and increasing travel demand encouraged the private sector to fill the gap (Imran, 1992). To overcome the address issues and to provide better, economic and standard public transport for inter-city and intra-city the Punjab Road Transport Corporation' (PRTC) and Punjab Urban Transport Corporation (PUTC) were established in the province of Punjab (Lahore Development Authority and World Bank/International Development Association, 1980). Later in 1991, National Transport Research Board published draft National Transport Policy addressing the bus public transport system as an advantage over the rail mass transit system for urban populated area (Imran, 1992). In 1992, Japan International Cooperation Agency (JICA) suggested heavy and light rail public transport for the city Lahore and with the passage of time under different schemes, varied public transport mode were introduced in different cities like Karachi, Islamabad, Rawalpindi, Faisalabad and Lahore but remained useless. In Punjab,

private sector was encouraged to provide efficient, rapid, comfortable and satisfactory public transport to the city Lahore under subsidize schemes (Imran, 1992). Till year 2004, more budget was allocated to build, maintain and operate the road network rather than on public transport (Imran, 1992). Government of Punjab in year 2005, conducted a study for the development of mass transit system and study recommend the four line rail mass transit system for the city Lahore (Imran, 1992).

In the last quarter of 2011, Pakistani and Turkish experts finalized the 20 year mass transit plans on the basis of the JICA study, conducted for the mass transit system. Construction of 27 km corridor named as Corridor 1 or Ferozepur Corridor was started in March 2012. Ferozepur road is one of the busiest arterial road passing through the heart of Lahore and it covers most of the CBD area of the city Lahore. Major industries, shopping clubs, universities, colleges, schools and business trade are densified by the corridor. The construction work was completed in year 2013 and bus based transit system was introduced in the city Lahore. This project was built on built operate and transfer (BOT) basis with the exclusive operational terms in the best interest of the public. The travel time saving, vehicle operating cost saving, release congestion, improve economic growth, safety and security free transport, additional revenue from the advertisement, employment opportunity benefits, provide better intra-city public transport and built on Public Private Partnership basis to minimize the financial issues were consider as core benefits form the newly introduced bus service.

It was expected that initially 9,000 commuters per hour per direction (pphpd) would travel in peak hour with projected increase of 24,000 pphpd over the time. The latest collected data on ridership reveals that more than 9,000 commuters are travelling in peak hour. To attract more commuters and for the successful operation it was initially designed to meet all BRTS standards. Lahore transport company (LTC) established in year 2009 under the ordinance act of 1984 is acting as regulatory authority in city to provide safe, efficient and economic service to the commuter. LTC is also responsible for the public transport infrastructure and to facilitate the private operators in the city Lahore. Since 2013,

Punjab Masstransit Authority (PMA) was established in Lahore to better operate and maintain the overall Metrobus systems in Punjab. The main features of the Lahore Metrobus corridor are as below

a. An isolated running way (elevated 8.3 km and at grade 18.7 km) is constructed along the entire length.
b. It has almost 27 km length starting from the Shahdara bus terminal to Gajju Mata bus terminal with intermediate bus stations.
c. Total 25 bus stations having dimension 81 m length and 3.5 m width are constructed along the corridor.
d. Almost 64 articulated air conditioned buses with four boarding doors are operating for almost 16 hours from 6:15 to 22:00.
e. It has crush commuter capacity of 160 commuters.
f. Daily ridership is approximately 130,000 commuters per day.
g. Adequate shelter and benches with the lighting and bracket fans arrangement are installed at each bus station to facilitate commuter and for safety purposes sliding doors are installed at each platform.
h. Audible announcement arrangement and security cameras are provided on each side of the station for arriving vehicle.
i. Air conditioned vehicles are integrated with LEDs displaying travel speed and Metrobus map.
j. The Metrobus depot is also provided.
k. Manual, smart card and automated fare collection machine are also provided at each station.
l. Lahore Metrobus is fully equipped with the ITS.
m. On average bus station distance is around 1038 m.
n. The PMA has developed the bus schedule of varied headway for peak hour and off peak hour windows for each week day.

2.5 Service Quality

The transit service quality is defined as “The overall measured or perceived performance of transit service from the passenger's point of view” (TCRP, 2014). Over the last three decade, service quality has become the arousing subject in

academic research and public as well as private sector (Kang and James, 2004). The trend has changed to customer focused service by improving the system performance on regular basis and in transport sector, service quality is a stuff of greatest concern as improved service quality will attract more commuter (Eboli and Muzzulla, 2008). Operational success of public transport will reduce traffic congestion problems, environmental problems, energy consumption and construction cost to accommodate more vehicle (Eboli and Mazzulla, 2008)

The transit service quality is greatly influence by the transit operator and its commuters (Eboli and Mazzulla, 2008). The transit agency provides the commuter service/ transit service by judging the commuter satisfaction perception and the prime objective of the agency is to attract more commuter by providing an expected level of service in a cost effective way (Eboli and Mazzulla, 2011; Xiyuan, 2014). On the other way, commuter perceives and judge the service base on their experience, needs and expectations. The commuter ride experience and expected satisfaction play vital role in their travel decision and diversity in the perception has provoked the apprehension to estimate the transit service quality accurately and broadly (Eboli and Mazzulla, 2011). To measure the transit service quality in term of subjective and objective scenario required actual enactment of the transit service provided by the operator and the commuter's satisfaction that used the service. Service quality investigation requires the commuter survey and it does not indicate the actual service performance rather it indicate the commuters judgment and experience. A site observation is done to investigate the aspects for which commuter's has showed diverse effect provided by the agency (Eboli and Mazzulla, 2011; 2012; Nathanail, 2008; Xiyuan, 2014).

To evaluate the transit service quality, numerous studies have been carried out and these studies highlight two types of research framework for transit service quality i-e subjective approach and objective approach (Eboli and Mazzulla, 2011; 2012 Nathanail, 2008; Xiyuan, 2014). Statistical analysis techniques to evaluate the commuter satisfaction survey/ commuter perception are carried out in subjective approach. For the objective evaluation, agency performance indicators are measured against the published recommended standards (Eboli and Mazzulla,

2011; 2012a; Nathanail, 2008; Xiyuan, 2014). From the counted researches on both approaches i-e subjective and objective approach to evaluate the transit service quality few are discussed below.

Subjective evaluation of transit service quality offered quantitative and qualitative statistical techniques. Luigi et al. (2010) assessed the commuter perception for the public transport and the way it change by using the available data. Further, researcher evaluated by comparing method that service perception of transit quality would change with the factors/indicators being conversant to the commuter. Beirao and Sarsfield-Cabral (2007) proposed some key factors by analyzing in-depth collected interviews data of regularized and on and off commuter of public transport and cars. His research revealed the importance of commuter perception to the service quality directly influencing the demand for each mode. Also, Yannis Tyrinopoulos and Constantinos Antoniou (2008) measured the inclusive commuter perception of transit service by using two statistical model i-e factor analysis and ordered logit model with diverse amplified data. This research methodology highlighted importance of transit quality with commuter's satisfaction including frequency and accessibility as two important indicators.

Public transit service performance measurements methodologies are adopted in objective approach. A few studies are found in the literature to measure the transit service performance for objective evaluation. A broad and well organized researches comprising all the dimension of transit service quality are published by the transportation Research Board (TRB) through the Transit Cooperative Research Program (TCRP) (Xiyuan, 2014). The Transit Capacity and Quality of Service Manual (TCRP, 2014) defined all the indicators that will influence in each stage of commuter's decision making process to use a public transport. Brief procedures and methodologies to evaluate service quality in view of system capacity, facility and operation is also entertained in the report. This report proposed framework to evaluate bus stop service performance level, bus transit system's capacity, commuter comfort level for various elements of the bus system and a method to evaluate factors affecting commuter perception of travel

(Xiyuan, 2014). To evaluate the mass transit service quality a methodology was developed by the Transit Cooperative Research Program (TCRP, 2001) and implement it to evaluate CTA Red and Blue Line service performance (Eboli and Mazzulla, 2012). Similarly Bertini and El-Geneidy (2003) proposed series of performance measures to improve the service quality from archived data.

Literature reveals limited methodologies/researches to measure the service quality in view of subjective and objective approach (Xiyuan, 2014). For example, Tyrinopoulos and Aifadopoulou (2008) did factor analysis and multinomial logistic regression analysis on 39 indicators compounded to seven factors to investigate the impact of operational performance indicators on commuter's satisfaction. Similarly Nathanail (2008) introduced a methodology to access the service quality of railway mode and performed quantitative analysis on 22 indicators grouped into six factors to investigate subjective judgment and objective indicators on the same scale for operation and maintenance of railway mode (Eboli and Mazzulla, 2011). In 2010, Laura Eboli and Gabriella Mazzulla proposed a comprehensive framework to evaluate the transit service quality from subjective and objective approach. They jointly did the subjective and objective measures of transit performance analysis followed by the comparison between the outcomes. Their methodology linked the objective performance measurement indicator to the commuter satisfaction survey to the public bus transit system (Xiyuan, 2014). To evaluate service quality of the Hefei BRTS in China, from subjective and objective scenario, Liu Xiyuan in 2014, analyzed commuter satisfaction survey data and field data by using different statistical techniques such as ANOVA test and factor analysis. The differences between the subjective analysis and objective evaluation determined the overall service quality of the Hefei BRTS.

CHAPTER 3

RESEARCH METHODOLOGY AND DATA COLLECTION

3.1 Introduction

The designed methodology is derived from the similar kind of study previously done (Xiyuan, 2014). The brief detail of the methodology is structured into subjective analysis and objective evaluation combing to overall service quality of the Lahore Metrobus. For subjective perception, commuter satisfaction survey is conducted. Next, the descriptive analysis of the commuters is done and the model predicting significant variables affecting overall satisfaction level is estimated. Collection of field data to elaborate the data analysis with the LOS is the key to objective evaluation.

The study framework comprises quantitative and qualitative approach for the overall commuter satisfaction and development of each step at each phase is imitative from the relevant studies. The brief of the research charter is discussed in this chapter. To integrate the research road map for urban quality bus service evaluation, demands extensive literature review. The very first step of enlisting all the characteristics and attributes of the bus service play vital role in the evaluation of transit service quality and defining the service quality indicators play vital role to understand service quality concept comprehensively. The structural framework listed below is adopted in this research.

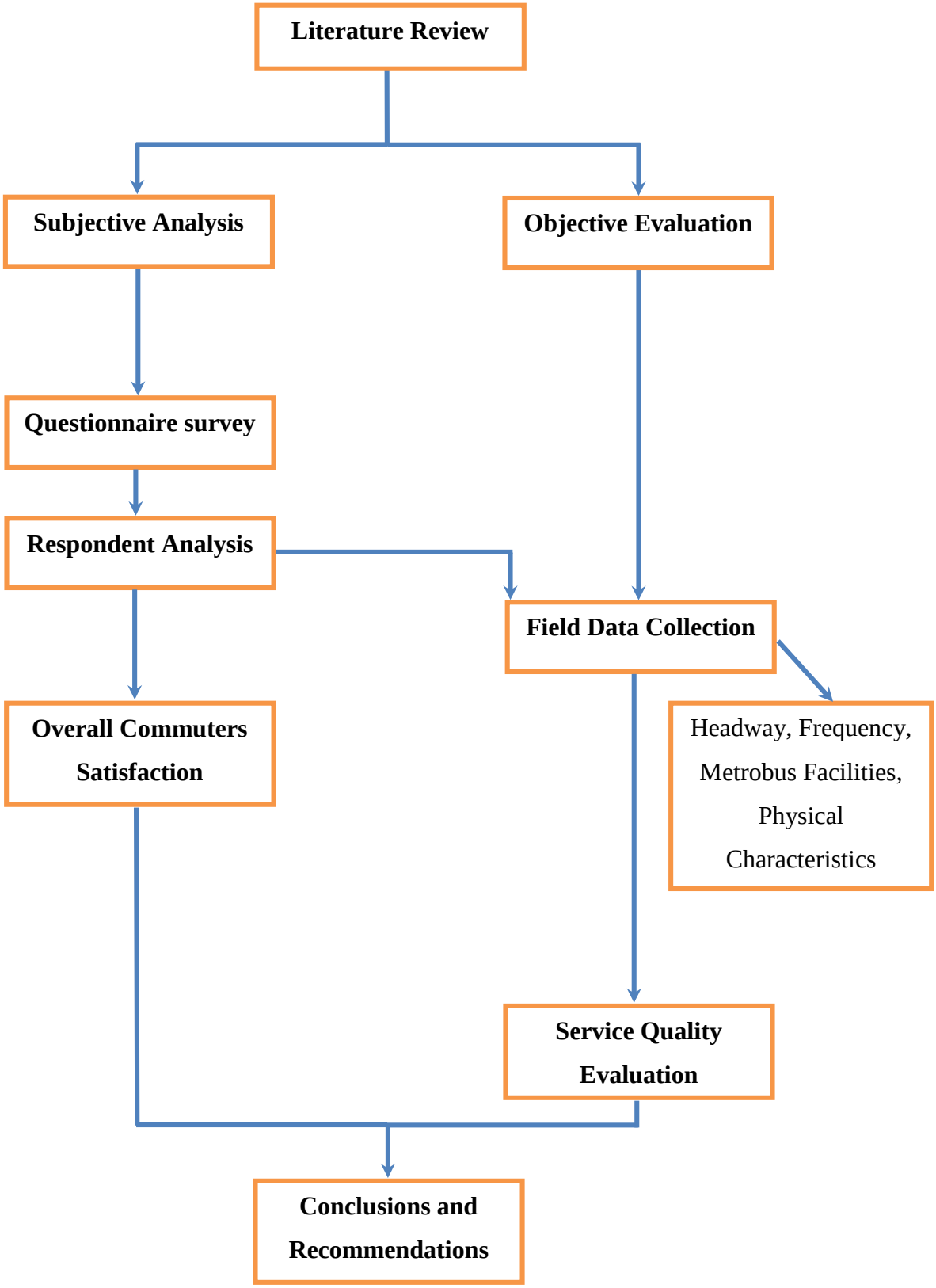

Figure 3.1: Structural Framework

Literature reveals all efforts to commuter satisfaction and service quality measurement besides defining and applying the service quality indicators for agency to measure its performance. Predominantly, the Transportation Research Board (TRB) USA, through the Transit Cooperative Research Program (TCRP), published some manuals and hand books to assess the commuter satisfaction in public transport (Transportation Research Board, 1999b) i-e calculating transit performance measures (Transportation Research Board, 2003a), and evaluating transit capacity and quality of service (Transportation Research Board, 2003b), bus route (Transportation Research Board, 1995a), customer information (Transportation Research Board, 1996; 1999a), transit bus service line and cleaning functions (Transportation Research Board, 1995b). Similarly, European Union (EU) countries made remarkable contribution to the service quality by conducting different research and programs i-e a manual to measure public transit quality was published by the European Committee for Standardization (European Committee for Standardization, 2002), QUATTRO (EU Transport RTD program, 1998), EQUIP (EU Transport RTD program, 2000), and PORTAL (EU Transport RTD program, 2003) and the Hellenic Institute of Transport presented and applied varied performance and quality indicators to control the quality of public transport for the agency (Hellenic Institute of Transport, 2003; 2005). Also Quality indicators were divided into three different aspects; value of journey time, availability, comfort and convenience (TCRP, 2014).

To measure the transportation service quality, researchers have characterized transportation quality aspects into different characteristics for better and easy understating to the commuter and commuter satisfaction survey developed should be easily understandable to the commuter. Laura Eboli and Gabriella Mazzulla (2010); Liu Xiyuan (2014), verbalized transportation quality aspects into different indicators to measure the transportation service quality. Review on the commuter satisfaction survey studies inferred the upcoming seven quality factors for the study.

Table 3.1: Indicators of Commuter Satisfaction

Reliability	• Bus Arrives on Time • Breakdown of Bus • Satisfaction with the Ticketing Procedure • Bus has schedule
Assurance	• Staff shows courtesy • Safe transaction with the staff • Safe inside the corridor
Comfort	• All time weather waiting area • Buses are well maintained • Attractive Service
Responsiveness	• Customer Service of staff • Efficient Service • Enough Staff • Save Travel Time
Availability	• Bus frequency • Suitable Operating Hours • Economic Service
Convenience	• Waiting Time • Travel Time in Bus/ Travel Speed
Accessibility	• Walking Distance • Interchange Facility

Source: Liu Xiyuan, 2014

Reliability is defined as the ability to perform the promised service dependably and accurately (Parasuraman et al., 1988; Ojo et al., 2014). It can be defined as "the ability of the transit system to adhere to schedule or maintain regular headways and a consistent travel time" (Turnquist and Blume, 1980). Service reliability is related to the certainty of vehicle arrival (Beirao and Sarsfield-Cabral, 2007). Short waiting time decreases the journey time and attracts

more commuter by improving the reliability (Xiyuan, 2014). Different studies on transit have revealed the fact that short waiting time is more important for the commuters than the elapsed travel time (Nash and Hille, 1968; Hartgen and Tanner, 1970). To evaluate the service reliability numerous indicators have proposed by the transit agencies. The three main indictors of service reliability are journey time reliability, headway/ dowel time reliability and consistent service reliability (Transportation Research Board, 2003; FTA, 2004). Strictly adherence to schedule and consistency in fix journey time is related to first two reliability factors, on the other hand assessing the system availability and dependability in view of commuters by considering the system characteristics are discussed in the service reliability (FTA, 2004). Studies discloses that there are many factors that affects the service reliability such as traffic conditions, breakdowns of service due to vehicle problem, signals problem, number of stops, consistence commuter flow and the use of wheelchair lifts/ramps (Eboli and Mazzulla, 2011). The reliability in this research comprises bus arrival time, breakdown of the bus, safe transaction with the staff and the most important one the bus schedule indicator.

Assurance sometime consider as derived aspect of reliability (Xiyuan, 2014). Although, service assurance play vita role to assess overall reliability of the system but for the easiness its performance is evaluated separately (Xiyuan, 2014). Safety and security are the two main indicators of service assurance and safety doesn't mobilize commuters to shift to other mode, therefore, probability to involve in an accident or victim of crime doesn't impact modal choice (Eboli and Mazzulla, 2011). To evaluate the overall performance of safety, assurance indicator play important role (Solomon et al., 1968). The safety of the commuter inside the corridor and a safe transaction with the staff showing courtesy boost the commuter trust on the service (Xiyuan, 2014).

Next, an essential qualitative aspect of transit bus service is comfort; called comfort. In this study, comfortableness of the service is associated with the bus station environment, vehicle environment and bus quality standards attracting more commuters. Vehicle maintenance refers as vehicle cleaning, seats cleaning and washing of the vehicle while clean buses have positive impact on the ridership and

promote its good image to the public (Transportation Research Board, 1995b). Commuter expects comfortable journey in BRTS rather than other conventional bus system (Xiyuan, 2014). These aspects purely represent operator's interest to commuter and attractive aspect of BRTS is perceived by its comfort indicator.

Happier and easier journey is assessed by the responsiveness aspect (Eboli and Mazzulla, 2011; 2012). To provide efficient, prompt and commuter caring service are the key attributes of the responsiveness indicators which play vital role to mode choice (Eboli and Mazzulla 2011; 2012; Xiyuan, 2014). Helpful and clear communication with the staff, staff professional appearance, staff physical appearance, easy access to ticketing office, active ticketing office and either transit agency has commuter interest at heart are the indicators compiled to address customer service of the staff (Eboli and Mazzulla 2011; 2012; Xiyuan, 2014). Last but not least a very important indicator of the responsiveness aspect is the travel time saving which is the key characteristics of the BRTS (Xiyuan, 2014).

The very important aspect of the BRTS performance evaluation is its availability (Xiyuan, 2014). The availability is perceived as "measures that assessing how easily potential commuters can use transit for various kinds of trips (TCRP, 2003)." The most important indicator governing to the availability performance aspect is the service time or operating hour of the service. Early in the morning and late at night service attracts more commuter by giving them an opportunity to travel on it (Eboli and Mazzulla 2011; Xiyuan, 2014). Another indicator included under the availability aspect is economic service to the commuter. Here, in this research economic service use exclusively for the fare as compared to commuters prior trip fare. Many researches have revealed that total cost of the travel is very important in modal choice decision (Eboli and Mazzula, 2011). Similarly, extensive work on transportation system alternatives depicts that travel cost does not impact the modal-choice decisions. For example, Wallin and Wright (1974), stated that "journey cost has very little impact on choice of a transportation mode". Beirao and Sarsfield-Cabral (2007), stated the cheaper concept of public transport compared to car and found that it does not impact the mode choice with few low income commuters who consider monetary value as

very important aspect. Eboli and Mazzulla (2011; 2012), consider the average one-way ticket cost as an indicator regarding ticket cost and compared it to the average cost of the ticket agencies operating in the similar state having equal transit service standards. The low bus fare level attracts more commuter by providing equal opportunity to all income group Eboli and Mazzula, 2011; 2012). Next, the most important indicators after the economic fare that involved in the decision making is the bus frequency (Eboli and Mazzulla 2011; Xiyuan, 2014). Higher bus frequency not only reduced waiting time and journey time but it also improve the overall reliability perception of the system. The operational performance is evaluated form the frequency indicator and one of the key indicator of the high frequency is on time rate (Eboli and Mazzulla 2011; 2012 Xiyuan, 2014). Adherence to the operator schedule is judged practically by the headway distribution. One of the main distinctive features of the BRTS is its high frequency (Eboli and Mazzulla 2011; 2012; Xiyuan, 2014).

Next, quality factor of the transit service is its convenience. Convenience of the transit service refers to the commuter waiting time at the bus terminal and the total travel time in the bus (Xiyuan, 2014). Bus transit speed is the principal indictor of the convenience aspect as commuters expect higher travel speed and short waiting time at the bus terminal while the operation success of the BRTS is greatly dependent on the convenience indictor (Xiyuan, 2014). Signal priority and exclusive right of way reduced the journey time by providing higher speed opportunity (Eboli and Mazzulla 2011; Xiyuan, 2014).

Accessibility is another quality attribute that is directly related to the service easiness. Two main factors interchange facility and walking distance measured the quality of accessibility for the transit system (Xiyuan, 2014). To access the BRTS by walking or other mode play vital role for mode choice and integrated BRTS provide unique modal choice to the commuter. All above cited indicators will determine the service quality and performance of the BRTS/ Lahore Metrobus.

3.2 Questionnaire Strategies

A comprehensive questionnaire comprises upcoming four parts is designed (see Annexure 'A'). The general information of the commuter like gender, age and number of automobile, income level, profession, family information, living place and licensed person in the family is incorporated in the first part. Second part of the questionnaire includes general travelling mode, time of travel and total travelled distance to get public transport prior to Metrobus. The third part of the questionnaire comprises the distance to get the Metrobus, mode to get Metrobus, purpose of travel, total daily travelled distance, daily travelled distance in Metrobus, weekly trips in Metrobus and the daily travelling time in Metrobus. Last but not least is quality indicator part of the questionnaire, the commuter are asked to rate the level of satisfaction for the present Metrobus service, bus service efficiency, customer service and frequency from the extremely satisfied, satisfied, neutral, unsatisfied and extremely unsatisfied option and summarizing all the service attributes are made to evaluate the overall service quality of Lahore Metrobus.

The minimum sample size of the survey is calculated from the following statistical equation developed by Yannis Tyrinopoulos and Constantinos Antoniou (2008).

$$n \geq N \left\{1 + \frac{N-1}{P(1-P)} \left(\frac{d}{Z_{a/2}}\right)^2\right\}^{-1} \quad (1)$$

where

n is minimum number of sample size

N is the daily total ridership that is 130,000 Commuters/Day

P is previously measured level of satisfaction or quality aspect, using first time take it neutral case supposing the value 0.5

d marginal error usually taken as 5 percent

$Z_{a/2}$ is confidence level taken to be 1.96 for the 95 percent confidence interval in this study.

In view of above the minimum sample size for the work is calculated to be in range of 363 to 403. To get better result, customer satisfaction survey were distributed among 460 individuals and 400 questionnaire were found valid.

3.3 Transit Service Performance Measure

Utilization of agency own resources to introduced final product and weighing its overall performance under its operating environment is called performance measurement (Transportation Research Board, 1994, 2004b). The transit service performance measure defines as "A quantitative performance measure that describes a particular aspect of transit service and represents the commuters' point of view" (TCRP, 2003). The transit management performance, operational and control management performance, competitive transit performance, public and operator's gap performance and transit authority board's performance can be evaluated by the performance measurement (Eboli and Mazzulla, 2011; 2012).

To measure the service performance, quality aspects are derived from the commuter satisfaction survey and performance measure can be categorized as quantitative or qualitative measure to evaluate or compare system standards and performance indicators are used as measurement tool to assess system's performance (Eboli and Mazzulla 2011; Xiyuan, 2014). Literature reveals schematic and articulated transit service performance measure with variation in selection from agency to agency (Xiyuan, 2014). To measure the performance of the transit system "Level of Service" (LOS) describing range of values is used in this research. To measure the level of service, TCRP have published standardized values against each transit performance aspects and these values are standardized base on its unique identity and diverse features from the other bus system (Eboli and Mazzulla 2011; Xiyuan, 2014).

To measure the transit service performance of Lahore Metrobus field data (speed, frequency, headway, travel time, amenities and physical characteristics) from both quantitative and qualitative aspects was collected from all the bus stations and bus terminals.

3.4 Statistical Approaches

The statistical approach comprises the statistical analysis of commuter's survey. In respondent's survey analysis; commuter's general information, travel pattern before and after the Metrobus and Metrobus service quality survey is discussed in detail. Commuter's overall satisfaction level estimated by the software is then used to evaluate the perceived level of satisfaction for each indicator.

In depth commuter satisfaction is assessed from the estimation of coefficient by modelling. Base on the explanatory variable researchers have suggested different models such as regression model, structural equation models (SEM) (Bollen, 1989), Logit models (Prioni & Hensher, 2000; Hensher, 2001; Hensher & Prioni, 2002; Hensher et al., 2003), ordinal regression technique (Siskos et al., 1998), impact score technique by Transportation Research Board, 1992 and Multinomial Logit Model (Prioni and Hensher, 2000; Hensher and Prioni, 2002). Similarly nestled logit model was suggested by Hensher et al. (2003), to compare the different service quality levels in and out of the bus agency. To observe the variation in the expectation of the commuters either observed or unobserved a mixed logit model was proposed by the Hensher et al. (2001). The ordinal nature of response variable may be categorical with continues values, restricting it to ordered probit model. Like other qualitative model for dependent variable, ordered probit model; a qualitative model was firstly used in bio-study by Aitchison and Silvey in the year 1957 and later in the year 1975 McKelvey and Zavoina come up with the use in the social sciences.

To analysis the commuter's satisfaction on multi-modal choices, probability model was applied which turned out to be binomial logit model base on the nature of the explanatory variable (Cees Gorter et.al., 1999). To estimate the bus service quality in view of commuter, structural equation model was used to find the relationship between commuter's expectation with the bus service quality aspects without taking into account the socio-economic background of the commuters (Eboli and Mazulla, (2007)). Similarly in 2008, Mintesnot Gebeyehu and Shin-ei Takano used two ordinal logit models to evaluate the commuter's satisfaction in view of their mode choice considering the commuter socio-

economic, demographic information, mode choice and travel characteristics. To analysis the commuter's satisfaction with different transport mode, four distinct ordered response models were used by interpreting seven factors i-e current residence, age, gender, family size, marital status, education level and occupation as independent variable and found four explanatory variable (gender, education level, occupation and current residence) to be significant with the response variable in Turkey (Ali, K.C., Ötüken, S., 2016).

In the best of the author, ordered probit model is never used till time to evaluate the service quality of the Metrobus. Similarly, based on the best knowledge of the writer, ordered probit model is selected on the ordinal and categorical nature of the data and to estimate the ordered probit model NLOGIT software is used. To make the model effective, ordinal data is labelled for the response variable (i-e neutral/low given as 1, satisfied as 2 and 3 for extremely satisfied level of satisfaction). The model specifications used here in this study are

$$S_n^* = U_n\beta' + \in_n \quad (2)$$

where S_n^* = latent and continuous response variable measuring overall satisfaction assessment level made by the n commuters

$U_n =$ vector of explanatory variable i-e gender, family size, driving license, traveling time prior to Metrobus, customer service of Metrobus staff, and bus frequency

β' = coefficient of explanatory variable to be estimated

$\in_n$ = random error term to be referred as standard normal distribution

The satisfaction response variable S_n^* is estimated by the selected model as below:

$$\text{Prob}(S=n) = \Phi(\mu_n - \beta U) - \Phi(\mu_{n+1} - \beta U) \quad (3)$$

where $\mu_{-1} = -\infty$, $\mu_2 = +\infty$, $\mu_0 = 0$ and μ_1 are the two thresholds in between which the ordinal responses are estimated while Φ is standard normal cumulative distribution function. In this study, three ordered categories (extremely satisfied, satisfied and neutral/ low) are coded for response variable 'S'. To get normal distribution curve we need one cut of value with a second threshold of $\mu_0 = 0$ (see figure 3.2) by maximum likelihood procedure (Kckelvey and Zavoina, 1975).

The association of the explanatory variable with the ordered discrete outcome is illustrated by the parameter β′. Positive value of β depicts an increase in 'S' with the surety towards highest probability for satisfaction i-e extremely satisfied level and equal decrease in the probability for the lowest satisfaction level i-e neutral/low and for negative value the scenario is opposite. The effects of the independent variable on the probability of the intermediate categories of response variable can be estimated from the marginal effects (Washington, Karlaftis et al., 2012).

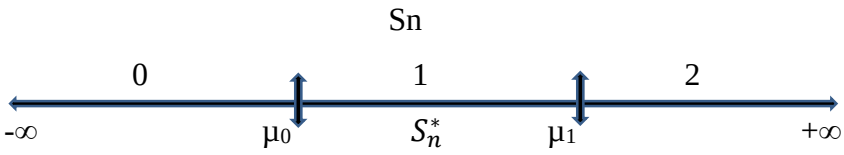

Figure 3.2: Relationship between Latent Overall Satisfaction Level and Coded Overall Satisfaction Level

The service quality attributes are then analyzed against the significant values i-e LOS given in literature to the service provider and at the end each service aspects are evaluated in comparison to the commuter satisfaction survey to assess the difference in the expectations of the commuters to the level of service provided by the Lahore Metrobus.

3.5 Commuter Survey Data Collection and Collation

To get data in the vicinity of the Lahore Metrobus corridor is subjected to authority permission. Prior to start the commuter satisfaction survey on each bus stop permission was requested from the PMA and pilot survey was collected to validate the questionnaire. On-street survey is done to collect questionnaire data subjected to randomness of the data to get better result. One major difficulty in collecting the questionnaire survey was short waiting time at each bus stop and on the other hand to convince the arriving commuter for the survey was found very difficult specially during peak time as everyone find no time to answer. Lack of awareness and security issues in Pakistan restricted the commuters to participate in the survey. Gender discriminant factor was another main barrier to get data from opposite gender. The security staff and PMA representative helped out to complete the survey. To make the data more precise to randomness, data was collected for

three peak hour windows (8:00-9:00, 12:00-13:00, 17:00-18:00) and three off peak hour windows (10:00-11:00, 13:00-14:00, 15:00-16:00) and targeted age group was 17-60 years. Commuter satisfaction survey data was collected in the month of March and April from 15th March to 10th April and about 87 percent commuter fully participate and encourage the commuter satisfaction survey. The respondent rate is basically replication of commuter population on each stop listed in the Table 3.2.

Table 3.2: Commuter Satisfaction Survey-Data

Serial No.	Station Name	Valid Respondent	Serial No.	Station Name	Valid Respondent
1	Shahdara	16	15	Kalma Chowk	16
2	Niazi Chowk	14	16	Model Town	14
3	Timber Market	12	17	Naseerabad	14
4	Azadi Chowk	15	18	Ittefaq Hospital	13
5	Bhatti Chowk	15	19	Qainchi	17
6	Katchery	12	20	Ghazi Chowk	16
7	Civil Secretriat	16	21	Chungi Amar Sidhu	15
8	MAO College	15	22	Kamahan	13
9	Janazgah	17	23	Attari Saroba	12
10	Qartaba Chowk	17	24	Nishter Colony	15
11	Shama	16	25	Youhanabad	13
12	Ichra	16	26	Dulu Khurd	14
13	Canal	16	27	Gajju Matta	16
14	Qaddafi Stadium	15		**Total**	**400**

Collation of the data, the very next step of data collection was done prior to input data in the software. Invalid data of missing values and extreme value was validate by using the average value. Except specific questions such as age, gender, living place etc. all data can be collated for analysis. The commuter questionnaires with lot of missing values and invalid data were discarded.

CHAPTER 4

RESULTS AND ANALYSIS

Collated data is proceeded and analyzed by the statistical analytical software i-e windows IBM SPSS 20.0 and NLOGIT 6.0. Commuter satisfaction survey analysis comprising general information of the commuter, travel pattern before the Metrobus and recent travel pattern is proceeded in the SPSS software. The significant factors are found from the ordered probit model estimated by the multinomial choice modeling software known as "NLOGIT".

4.1 Respondent Analysis

4.1.1 Respondent's General Information Analysis

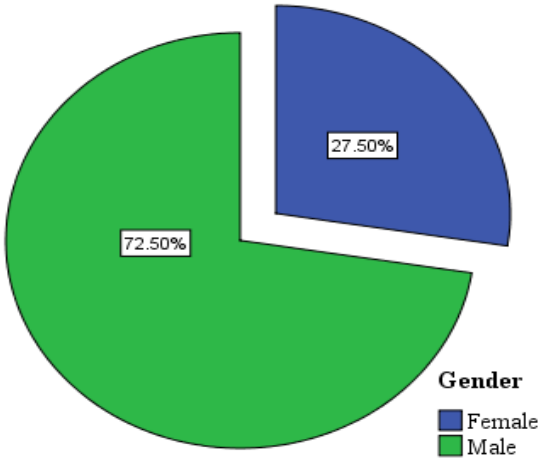

Figure 4.1: Commuter's Gender Distribution

The gender distribution of the sample population is clearly depict from the chart 4.1 indicating that dominant gender class belongs to men as compared to female. Working female ratio is higher in large cities as compared to intermediate/ small cities although overall country population have almost equal ratio to male and female.

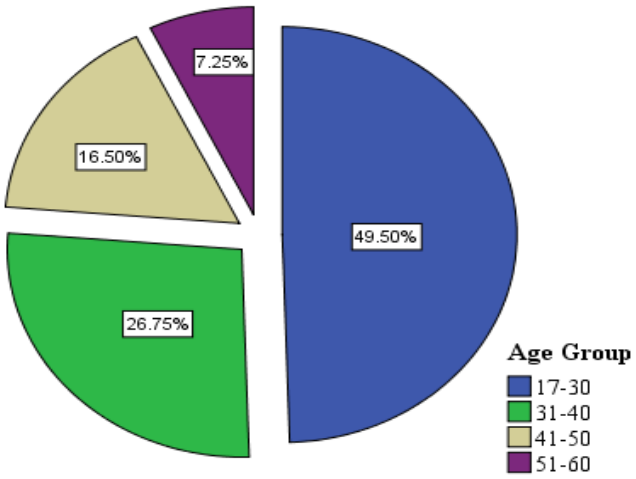

Figure 4.2: Commuter's Age Group Distribution

The age group distribution of the commuter using the Lahore Metrobus reveals the leading age group of 17-30 years followed by age group of 31-40 years having contribution of about 27 percent of the total. During the survey, priority was given to the younger commuter instead of old commuter having age above 60 years and unfortunately few commuters older than 60 years were observed travelling on Lahore Metrobus.

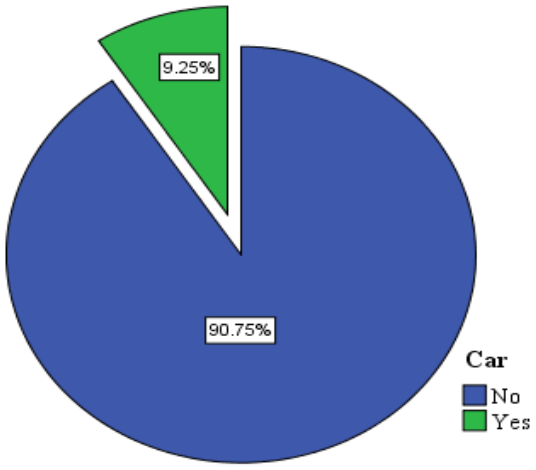

Figure 4.3: Commuter's Car Ownership

The figure 4.3 indicates that only 9 percent commuter travelling in the Lahore Metrobus have their own car or they have at home. The lower ownership of the car reflects commuters' life style standard and limited resources. The car

ownership is meant any person among family like brother, sister, mother, father, uncle or sister in law living with the interviewer own a car or not.

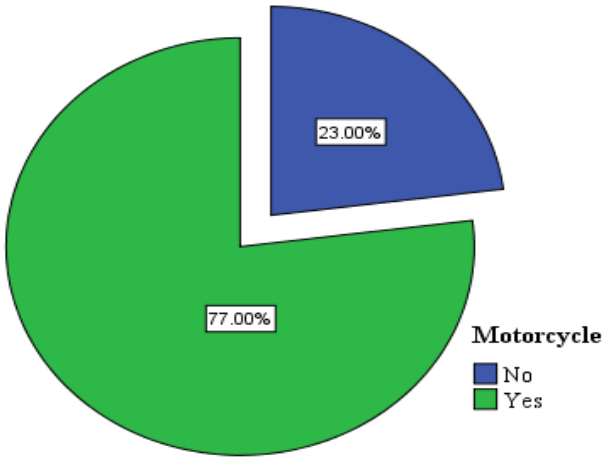

Figure 4.4: Commuter's Motorcycle Ownership

Most of the commuters' who are using the Metrobus as travel choice have their own motorcycle or having with family member at home i-e 77 percent. The higher motorcycle demand in the Lahore city is due to road congestion problem and mostly young commuter used motorcycle for school, college, university, shopping and recreational purposes.

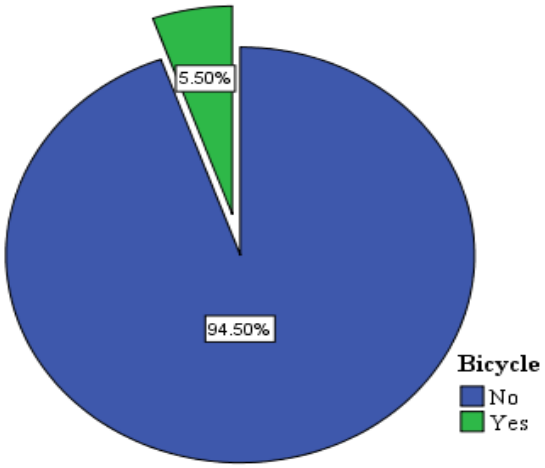

Figure 4.5: Commuter's Bicycle Ownership

Increasing automobile demands have reduced the bicycle demand in large cities and survey has disclosed that only 5.50 percent commuters have bicycle at

home that used their children for recreational purposes. Now, it is as easier to own a motorcycle as previously was to own a bicycle.

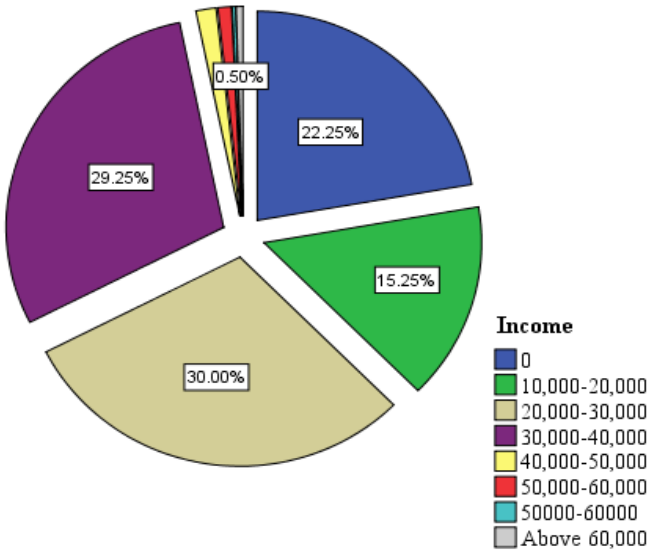

Figure 4.6: Commuter's Income Distribution

The pie chart in figure 4.6 shows that about 22.25 percent of the Lahore Metrobus commuters having zero income level are either student, trainer or house wife. Following the zero income level group, dominant income group of the Metrobus commuters' is 20,000-30,000 PKRs per month combining with the income group of 30,000-40,000 PKRs per month contribute almost 60 percent of the total commuter income group and about 15.25 percent commuter income falls in range of 10,000-20,000 PKRs per month category. This analysis indicates that low middle class prefer to use Metrobus and only 0.5 percent commuters' monthly income above 40,000 PKRs depicting less attraction for upper middle class income group. The affordability of the private automobile directly relates with the income level and as the income level increases commuters' shift to the private vehicle.

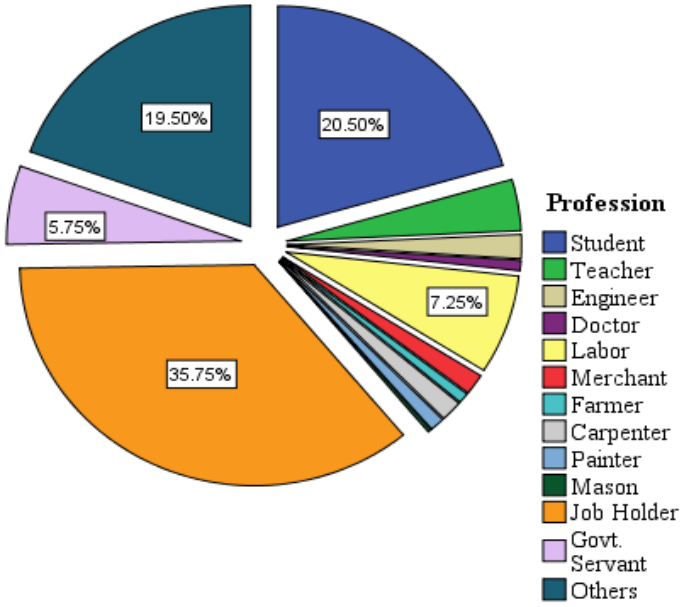

Figure 4.7: Commuter's Professional Distribution

The professional distribution in figure 4.7 elucidates that two main occupational group student and job holder are the dominant commuters of Lahore Metrobus. Their total contribution is about 57 percent and the third largest contribution is 19.50 percent for the 'others' profession. The others profession include house wife, tailor, salesman, businessman, fisher, lawyers, trainer, cricketer and job hunters. Govt. Servant contribution is about 6 percent of the total commuters.

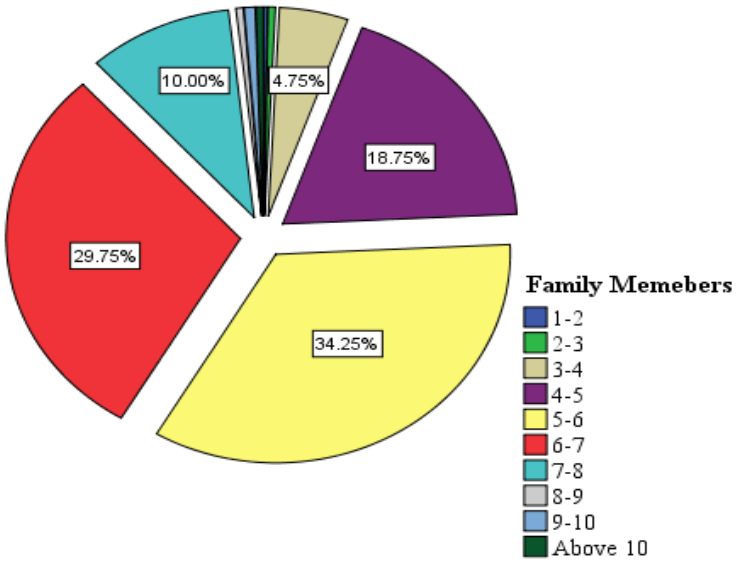

Figure 4.8: Commuter's Family Member Distribution

The pie chart in figure 4.8 indicates that family size of 5-6 members' is the dominant category using Metrobus i-e 34.25 percent and commuters having 7 family members is the second most Metrobus commuters' class. About 92 percent of the total commuters have family size range from 5 to 8 members.

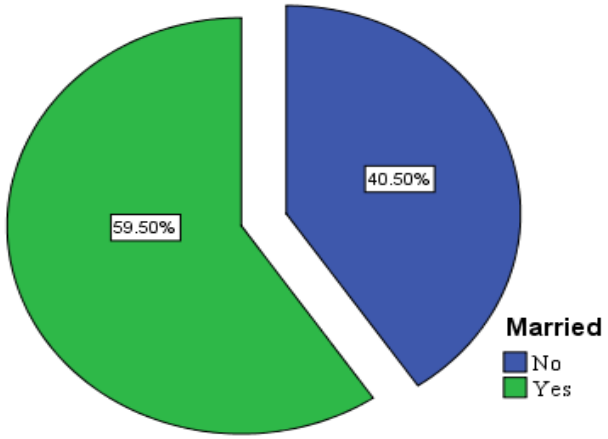

Figure 4.9: Commuter's Martial Status

The pie chart in figure 4.9 indicates that about 60 percent of the total Lahore Metrobus commuters are married and the rest 40 percent unmarried commuters are mostly women, students, few job holder and some are from other profession.

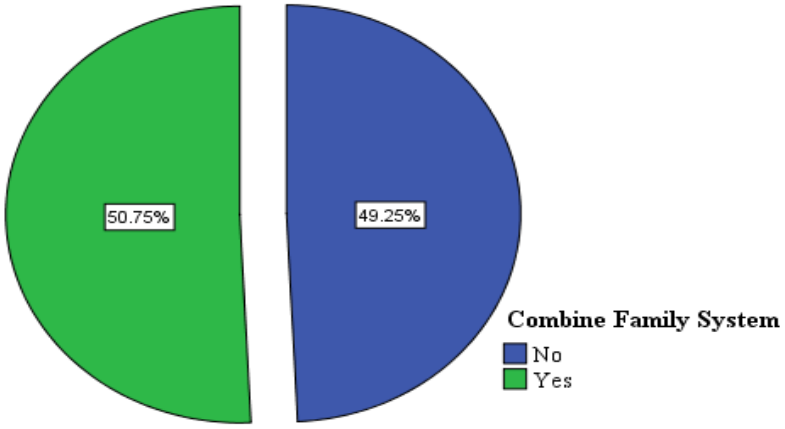

Figure 4.10: Commuter's Family System Distribution

Unemployment, low income level, limited resources and large family sizes encourage combine family system in Pakistan. From the interviewed, it was inferred that mostly commuters are supporting their family although they are living

in separate family system. The above cited chart in figure 4.10 shows almost equal distribution for combine and separated family system.

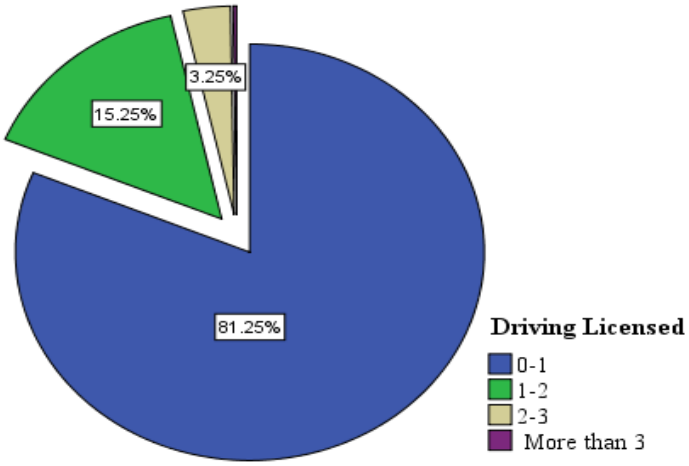

Figure 4.11: Commuter's Driving License Distribution

Majority of the Metrobus commuters have own source of travel either car or motorcycle that commuters' used in case of any breakdown of the service. The traffic enforcement law can depict from the pie chart in figure 4.11, as only 18 percent of the commuters have more than one driving license. Most of the commuters' about 82 percent either don't have any driving licensed or having just one individual driving licensed in the family. The statistical analysis of the general information reveals the following findings

- Lahore Metrobus is not attractive to old age (above 50) commuters.
- Lahore Metrobus is not an attractive service for car owners.
- Lower middle class commuters (with income level 20,000-40,000) is using Lahore Metrobus.

4.1.2 Commuter's Travel Characteristics Analysis

The part of the analysis includes two type of travel characteristics of the road user; first travel characteristics before Metrobus and second commuter recent travel characteristics. The competitiveness of Metrobus with other mode and travel time will be addressed here.

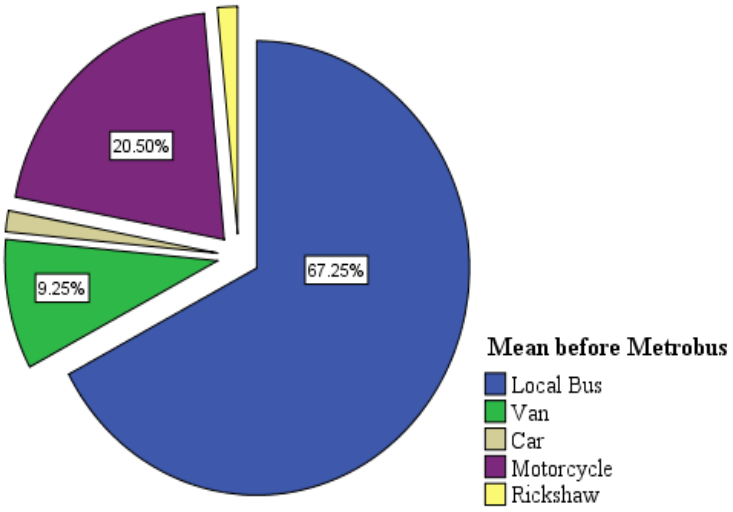

Figure 4.12: Commuter's Mean before Metrobus

Figure 4.12 illustrates that competitive mode of Lahore Metrobus is conventional local bus contributing almost 67 percent of the total commuters. The second leading mode choice of the commuters' prior to Metrobus is motorcycle which is about 21 percent of the total commuters. The percentage of van as mode choice is found to be 9 percent and around 3 percent of the total commuters are found to use rickshaw and their cars as mode choice for daily travel.

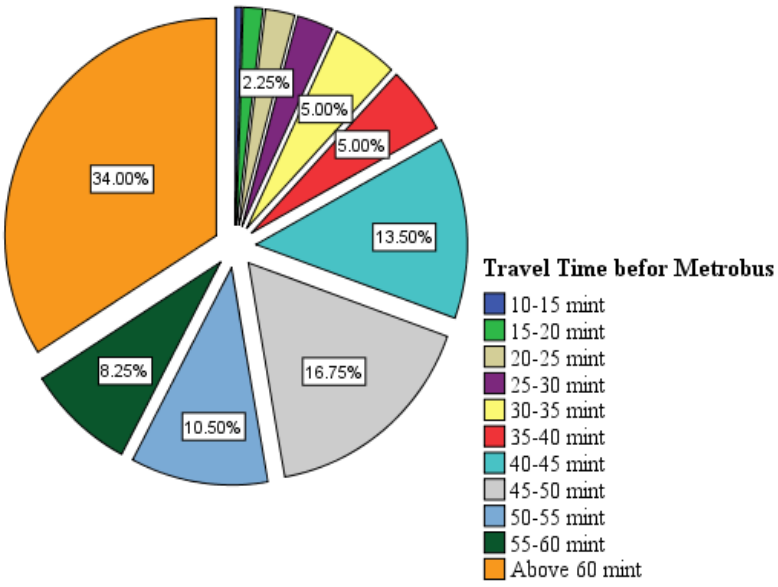

Figure 4.13: Commuter's Travel Time before Metrobus

The short travel time play vital role to attract more commuters to the service. The chart in figure 4.13 shows that total travel time for most of the Lahore

Metrobus commuters' i-e 34 percent before the operation of Lahore Metrobus was more than 60 minutes to complete their journey. The next four categories of travelling time ranges from 40-45 mint to 55-60 mints comprises about 49 percent of the total commuters. This shows that most of the commuters have to travel for longer time to reach their destination.

Cross Tabulation listed below demonstrates total travelling time spent by the commuters in different mode to reach their destination

Table 4.1: Cross Tabulation of Total Travelling Time and Mode before Metrobus

Travel Time before Metrobus	Mode before Metrobus					Total
	Car	Local Bus	Motorcycle	Rickshaw	Van	
10-15 mint	0	0	2	0	0	2
15-20 mint	0	5	1	0	0	6
20-25 mint	0	2	5	1	1	9
25-30 mint	0	3	7	0	1	11
30-35 mint	0	10	6	0	4	20
35-40 mint	0	13	5	2	0	20
40-45 mint	2	28	18	1	5	54
45-50 mint	1	41	22	1	2	67
50-55 mint	1	32	5	0	4	42
55-60 mint	0	24	4	0	5	33
Above 60 mint	2	111	7	1	15	136
Total	**6**	**269**	**82**	**6**	**37**	**400**

The Table 4.1 indicates that majority of the local bus commuters had to spend more than one hour to reach their destination while among the different mode choice when travelling time was in between 40-50 mints commuter liked to use their own automobile. This reveals that Lahore Metrobus is considered to be preferable choice for longer trip distance.

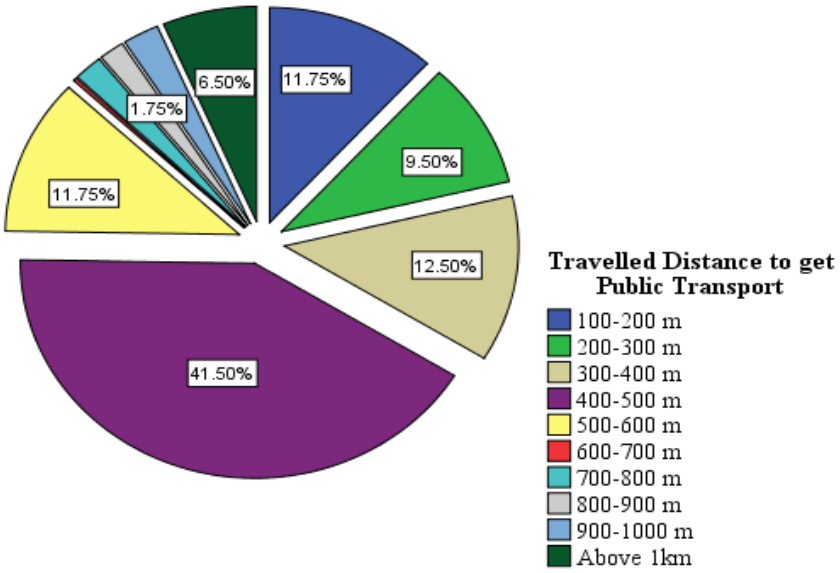

Figure 4.14: Commuter's Travel Distance to get Public Transport

An easy access to local public transport prior to Metrobus is observed (figure 4.14) and it is found that majority of the commuter had to walk 400-500 m to get the local public transport. The first four categories; 100-200 m, 200-300 m, 300-400 m and 400-500 m comprise about 75 percent of the total Metrobus commuters to get local public transport prior to their mode choice as Metrobus. Only 25 percent commuters were found whose travelling distance to get local public transport was more than 500 m.

In the second part of commuter's travel characteristics, the recent traveling characteristics of the commuters are analyzed.

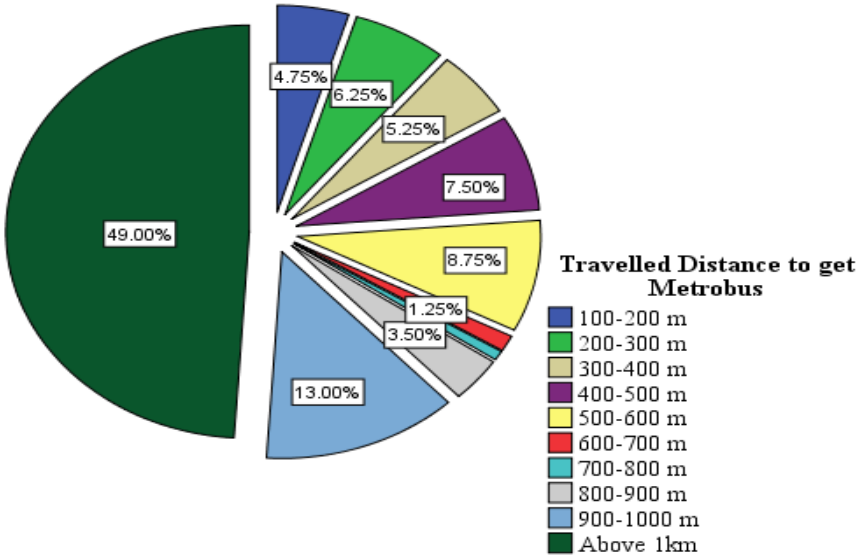

Figure 4.15: Commuter's Travelled Distance to get Metrobus

The pie chart in figure 4.15 is true representation of travelling distance for the Metrobus commuters to get Metrobus. Previously 75 percent commuters had to travel around 500 m distance to get the public transport while in the recent travel patterned only 31 percent commuters falls in this category. Almost 49 percent of the commuters have to travel more than 1 km to access Metrobus as Ferozpur road is passing through the central part of the city so commuter travelling in or out from all the directions to access Metrobus have to travel more than 1 km.

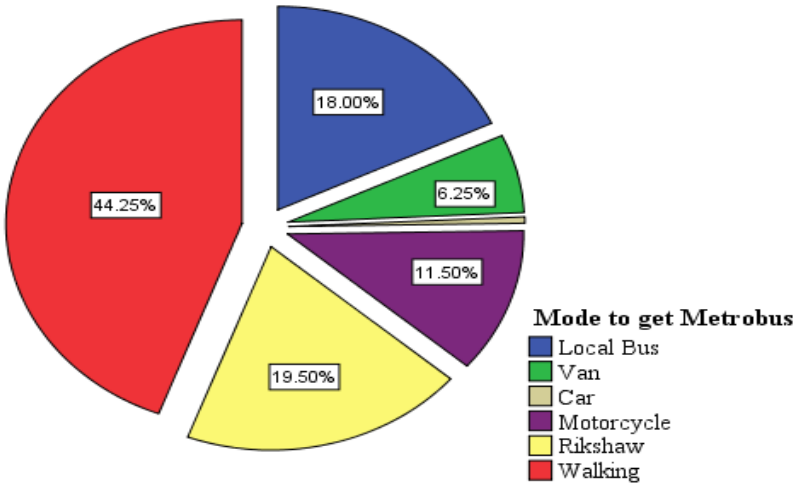

Figure 4.16: Commuter's Mode to get Metrobus

The key indicator of accessibility is walking distance. The pie chart in figure 4.16 indicates the perception of accessibility and commuter seems to be satisfied with the accessibility aspect as about 44 percent of the commuters assessed Metrobus by walking. The second highest percentage of travel mode to get Metrobus is rickshaw and then third is the local bus. Females are mostly dropped at Metrobus stations by mean of motorcycle. There is no park and ride facility available for the commuters.

Cross Tabulation between the mode to assess Metrobus and the travelling distance to reach at Metrobus station is created to analysis the mode choice of the commuters and their travelling behavior.

Table 4.2: Cross Tabulation of Mode to Get Metrobus and Travelled Distance to Get Metrobus

Travelled Distance to get Metrobus	Mode to get Metrobus						Total
	Car	Local Bus	Motorcycle	Rickshaw	Van	Walking	
100-200 m	0	1	1	1	0	16	19
200-300 m	0	1	0	2	0	22	25
300-400 m	0	1	2	0	0	18	21
400-500 m	0	0	1	0	0	29	30
500-600 m	0	1	6	0	0	28	35
600-700 m	0	0	0	0	0	5	5
700-800 m	0	0	0	1	0	2	3
800-900 m	1	3	0	2	1	7	14
900-1000 m	0	2	8	9	3	30	52
Above 1km	1	63	28	63	21	20	196
Total	2	72	46	78	25	177	400

Commuters are still using local public bus and rickshaw as travel mean for 1 km or above distance to assess Metrobus. From the Table 4.2 it can be inferred that still local public transport (i-e local bus and van) is another competitive mode of travel for longer trip. Most of the commuters whose mode of travel to get Metrobus is walking for 1 km or above distance are actually using local bus to drop nearby Metrobus station and then asses the Metrobus by walking.

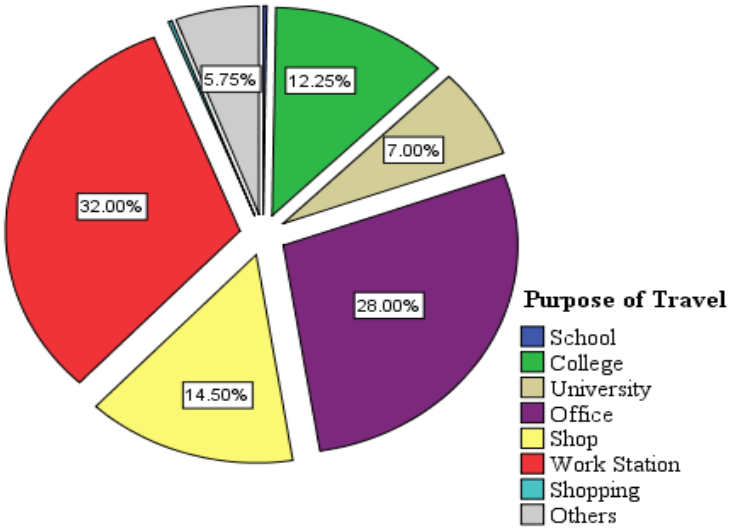

Figure 4.17: Commuter's Purpose to Travel

The pie chart in figure 4.17 indicates that 32 percent commuter are using Metrobus to reach their work station destination and profession that falls in this category are tailor, salesman, labor, worker, carpenter, painter, doctor, nurse and merchant. College and university student's ratio is 19 percent of the total commuters. Commuters travelling to their offices and shops by Metrobus contribute 28 and 14.50 percent of the total respectively.

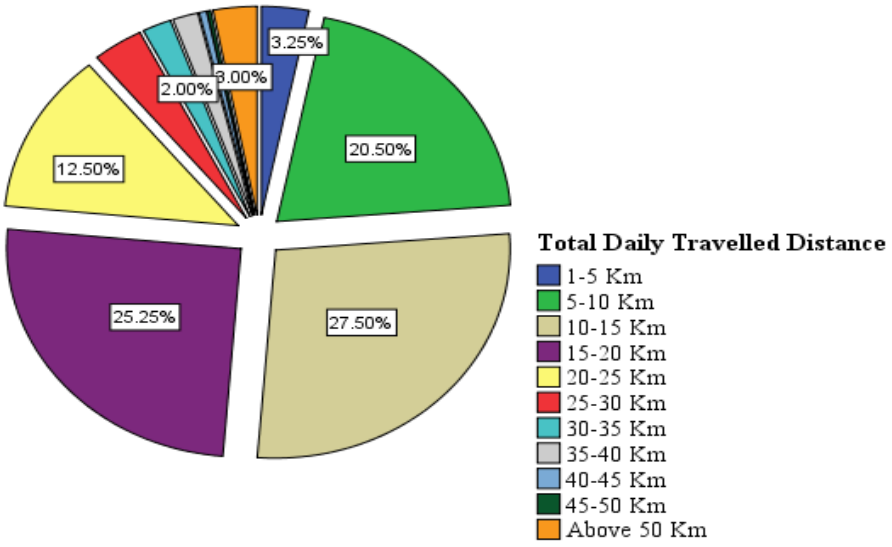

Figure 4.18: Commuter's Total Daily Travelled Distance

The total daily travelled distance of the Metrobus commuters is illustrated from the pie chart in figure 4.18. The one sided total daily travelled distance of the Metrobus commuters is found to be in range of 5-25 km (almost 85 percent of the

commuters). Commuters travelling more than 25 km distance are about 12 percent of the total commuters.

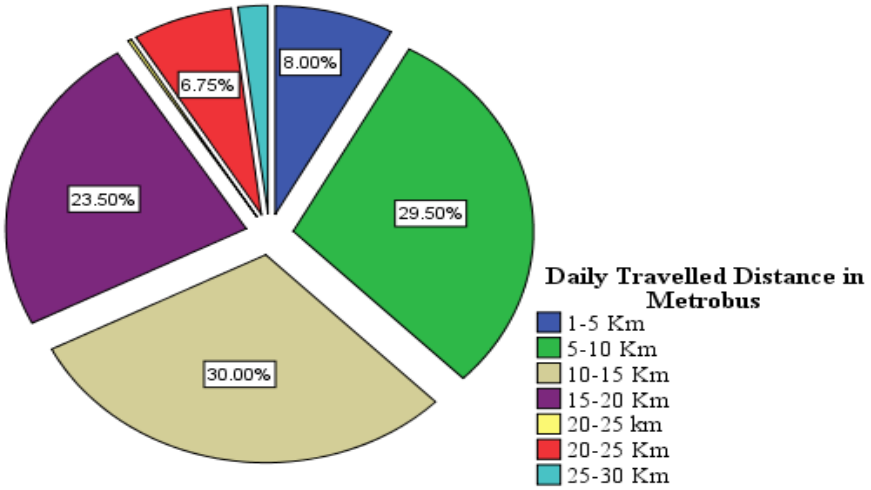

Figure 4.19: Commuter's Total Daily Travelled Distance in Metrobus

Figure 4.19 indicates that 60 percent of the Metrobus commuters are travelling 5-15 km on daily basis for one sided trip either from home to destination or destination to home. Around 33 percent commuters of are travelling more than 15 km distance in Metrobus on daily basis for one side trip. It was very difficult for the commuters to infer about the exact travelled distance in Metrobus so their origin to destination stop distance was estimated prior to proceed the data.

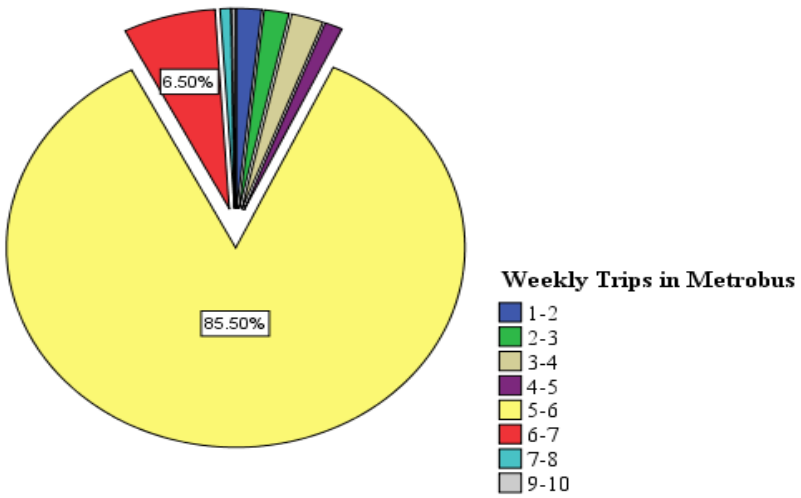

Figure 4.20: Commuter's Weekly Trip in Metrobus

The chart in figure 4.20 shows that about 85 percent commuters are traveling regularly on Metrobus for six days and the percentage of the commuters

using Metrobus for more than six trips in a week for one sided journey is almost 7 percent. A very few of the commuters are using it for either shopping, recreational activity, for meeting or some other personnel works.

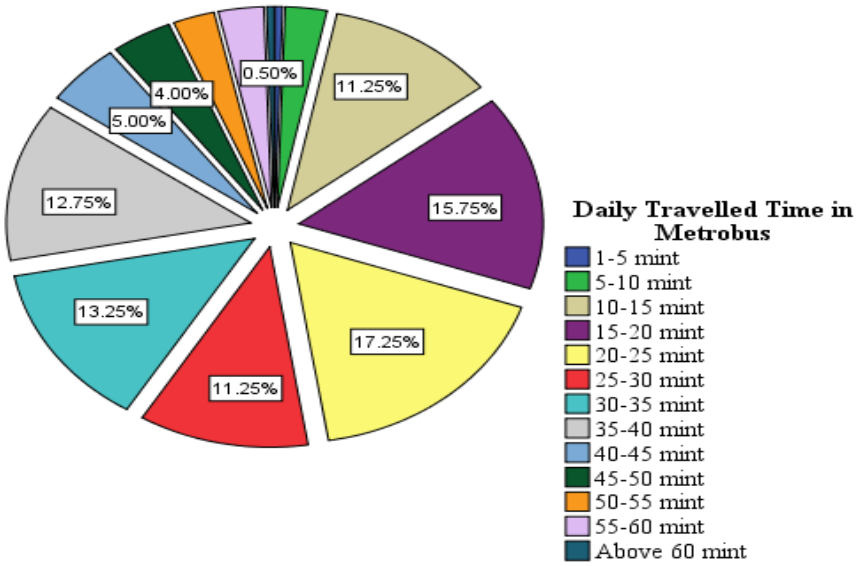

Figure 4.21: Commuter's Total Daily Travelled Time in Metrobus

The total daily travelled time for the single trip of the Metrobus commuters can be explained from the chart cited in the figure 4.21. The exact travelling time was not known to commuter however they answered on average basis. To calculate the exact travelling time an excel sheet was developed in view of the operating characteristics. Majority of the commuters travelling time is 20-25 mint that is 17 percent and almost 55 percent of total commuters travelling time is ranges from 10 mint to 30 mint. The percentage of commuters travelling in Metrobus more than 30 mints is about 45 percent and this depicts that Lahore Metrobus is not only an attracting service to short distance commuter but it is also an attractive service for larger travel journey commuters.

Commuter travel's characteristics reveals the upcoming enlisted findings

- Shifting of the commuter from local public transport to Metrobus indicates its attractiveness and loyalty to the commuters.
- Although most the commuters have to cover more than 1 km distance to reach Metrobus but still it is preferable mode of choice.

- Lahore Metrobus as daily travel choice to the commuters inferred that it is trust worthy and efficient service.

4.1.3 Lahore Metrobus Commuters' Satisfaction Survey

The most important part of the respondent analysis is to evaluate the overall satisfaction level of the commuters in view of the diverse satisfaction attributes or indicators. To proceed the analysis in the software the overall satisfaction attribute is coded as 1 for neutral level, 2 for satisfied level, 3 for extremely satisfied level, 4 for unsatisfied level and 5 for the extremely unsatisfied level. Base on the mean numeric value for the overall satisfaction level, evolution of the other attributes is done.

Table 4.3: Lahore Metrobus Commuters' Overall Level of Satisfaction

N	Mean	Std. Deviation
400	2.58	.515

The Table 4.3 discloses the overall satisfaction fact of the 400 randomly selected Lahore Metrobus commuters. The mean numeric value indicates that overall commuter satisfaction perception is higher than the satisfaction level and slightly lower than the extremely satisfaction level. To check the overall perception of the commuters to the Lahore Metrobus service quality, mean value of each indicator is compared with the mean value of the overall satisfaction level given in the upcoming Table. As many of the indicators were asked for extreme values "Yes" and "No", these values are given a scale of 3 for 'Yes' considered as extremely satisfied and 0 for 'No' associated it with neutral or low values.

Table 4.4: Commuters' Satisfaction Perception for Each Indicator

Indicator	Mean	Satisfaction Level
Metrobus arrives on time	3.00	
Breakdown of Metrobus	3.00	
Satisfied with Ticketing Procedure	3.00	Extremely Satisfied
Follow Schedule or move Casually	3.00	
Staff Courtesy	3.00	
Safe Transaction	3.00	Extremely Satisfied
Security Arrangement	3.00	
All Weather Waiting Area	3.00	
Well Maintained Buses	3.00	Extremely Satisfied
Attractive Service	3.00	
Customer Service of Staff	2.71	
Efficiency Satisfaction Level	2.51	
Sufficient Staff	3.00	Satisfied to Extremely Satisfied
Save time	3.00	
Satisfaction with Frequency of Bus	2.10	
Suitable Operating hours	3.00	Satisfied to Extremely Satisfied
Economic Service	3.00	
Waiting time	2.95	
Daily Travelled Time in Metrobus/ Travel Speed	3.00	Extremely Satisfied
Travelled Distance to get Metrobus	2.10	
Interchange Facility	3.00	Satisfied to Extremely Satisfied

Satisfaction levels of all the quality indicators are concise in the Table 4.4. The mean values of all the indicators range from 3.00 (extremely satisfied) to 2.10 (slightly higher than satisfied). So, satisfaction level is categorize as satisfied to extremely satisfy. Table 4.4 shows that although Metrobus commuters are satisfied

with the frequency of bus indicator but lower mean value assessment than overall satisfaction level mean value for efficient service and bus frequency may be the perception of unavailability of seats and overcrowding in the bus during peak hour window. Commuters are extremely satisfied with the waiting time as most of the commuters have to wait only for 0-5 mints in peak and off peak hours with exceptional waiting time of 5-10 mints. To incorporate the walking distance indictor in the Table 4.4, travelled distance to get Metrobus is enlisted. Literature recommends 400-500 m walking distance as standard for evaluation of walking distance quality indicator while majority of the commuters (60 percent) have to travel more than 600 m distance to get Metrobus and for the convenience and further analysis, this indictor is adjusted to satisfy level.

4.2 Modal Estimation Results

Due to categorical and ordinal nature of the response variable an ordered probit model has been introduced in this study. To see the latent correlation between the latent response variable with the observed response variable, overall satisfaction level is coded as 1 for neutral/low level, 2 for satisfied level and 3 for extremely satisfied level of satisfaction with the mean 0 and variance 1 assuming a normal distribution with two cut of values. The association of independent variable with the overall satisfaction level of Lahore Metrobus is illustrated by the estimation coefficient calculated against a t-test value of 1.96 of 95 percent confidence interval.

The indexed nature of various response variable in view of order response variable “overall satisfaction level” is estimated by ordered probit model. To estimate the random parameter all the possible combination of the explanatory variables were tried in the model and results of the model estimation are enlisted in the Table 4.6, with the six variables found to be statistically significant (Table 4.5). The gender group, family size, travel time per trip prior to Metrobus, customer service of the Metrobus staff and bus frequency were found to have positive statistical association with the response variable (overall satisfaction level of the commuters) while number of individual with valid driving license in a house was found to be negative association with the response variable.

In the category of gender of the Lahore Metrobus commuters, the results (Table 4.6) indicate that propensity of high satisfaction level from Lahore Metrobus increases if commuter is male and it is in consistent with the previous researches (Tyrinopoulos and Antoniou, 2008; Al-Atawi and Saleh, 2014; Dölarslan, 2014; Román et al., 2014; Ali, K.C., Ötüken, S., 2016). In Lahore Metrobus limited seats are designated for females which increases their waiting time at station and discomfort during travel while standing in bus thus decreasing their satisfaction level from the service. In vehicle crowding, lesser seat capacity is special concern to personnel safety and comfort to minimize overall satisfaction level (van Lierop, et al., 2017). Also, being a male dominated society there are certain social issues for females specifically during evening travel which decreases their satisfaction from the service. Travel early in the morning and late at night, safety and security at odd time and remote places can make women less comfortable from the service (Peters, 2002).

Moreover, family size also significantly affects commuters' satisfaction level from the Metrobus (Table 4.6). The results related to large family size (family members greater than five) of the commuter reflects a higher probability of higher commuters' satisfaction and lower probability of neutral/low commuters' satisfaction from the Metrobus service and it interesting and new finding so far. Thus is not surprising because as family size increases (keeping all other variables at their mean values) so the capacity of such families for affording private cars or other standards vehicles decreases which means that they used to travel via conventional public transport in the city prior to Metrobus thus Metrobus enhanced their satisfaction level. To fulfill the necessity is the first preference rather than luxury to the large family.

Travel time is as important as frequency which impacts the overall satisfaction level and mode choice (van Lierop, et al., 2017). Travel time per trip before Metrobus also affects the commuters' satisfaction (Table 4.6). The developed model shows that higher travel time of the commuter prior to start of Metrobus (more than 25 minutes) leads to higher likelihood of the higher commuters' satisfaction from the service i-e minimized travel time in Metrobus

higher the probability to be more satisfied (Mouwen, 2015; Stuart et al., 2000). Greater travel time prior to Metrobus addresses the lower efficiency and congestion issues while traveling via mix traffic which is frustrating as compared to the Metrobus which follows a regular schedule and has uninterrupted flow via its dedicated right of way (Government of Punjab, 2015).

Decent customer service of Lahore Metrobus increases the probability of commuters' satisfaction and decreases the likelihood of the low/neutral satisfaction level (van Lierop, et al., 2017). Lahore Metrobus offers a decent and well organized customer service which enhances commuters' confidence and satisfaction as compared to the traditional transporters and their behaviors in the city. Additionally, the effect of Metrobus frequency is found in positive association with commuters' satisfaction from the Metrobus (Table 4.6). It was revealed that higher the commuters' satisfaction from frequency of Metrobus so greater would be the probability of high level of commuters' satisfaction from Metrobus. It is due to the fact that Metrobus, unlike other public transport modes, have lower travel time which enhances commuters' satisfaction. This finding is in consistence with the past research (van Lierop, et al., 2017). Finally, the model revealed that as number of family members owning driving license increases so the probability of higher level of commuters' satisfaction decreases (Table 4.6) which address the sound financial condition of the family which leads to lower satisfaction from Metrobus as they have better accessibility via their own cars to perform various socio economic activities (Flórez, J., 1999).

As Ordered Probit Model can only predict the impacts of the specific independent variable on the probabilities of the extreme categories of the response variable. In order to understand the effect of change in value from 0-1 in the independent variable on the probabilities of the in between categories of the commuters' satisfaction level from Metrobus, marginal effects have been estimated in the Table 4.7 (Duncan, Khattak et al., 1998; Washington, Karlaftis et al., 2012). Moreover, value of adjusted rho-squared (ρ^2) is 0.25 which indicates reasonable overall goodness of fit of the model (McFadden, D., 1974).

Table 4.5: Description of Significant Variables

Variable	Description
Male commuter indicator	1 if commuter on Metrobus is male, 0 otherwise
Family size indicator	1 if number of family members of the commuter is greater than 5, 0 otherwise
Travel time per trip indicator	1 if travel time of the commuter per trip prior to Metrobus is greater than 25 minutes, 0 otherwise
Customer service indicator	1 if commuter's satisfaction level from customer's service of Metrobus is good or excellent, 0 otherwise
Bus frequency indicator	1 if commuter's satisfaction level from frequency of Metrobus is high, 0 otherwise
Driving license indicator	Number of family members owning driving licenses

Table 4.6: Estimation Results of Ordered Probit Model

Variable	Coefficient	t-stat
Constant	0.826	1.960
Male commuter indicator	0.362	2.260
Family size indicator	0.637	3.812
Travel time per trip indicator	0.746	2.292
Customer service indicator	1.209	7.873
Bus frequency indicator	1.230	5.546
Driving license indicator	-0.273	-2.099
μ_1	2.661	11.928
Number of observations	400	
Degrees of freedom	6	
Log likelihood	-221.53	
Restricted log likelihood	-297.26	
Adjusted rho-squared (ρ^2)	0.2547	

Table 4.7: Marginal Effects

Variable	Low/Neutral	Medium	High
Male commuter indicator	-0.0020	-0.1363	0.1383
Family size indicator	-0.0048	-0.2408	0.2456
Travel time per trip indicator	-0.0094	-0.2816	0.2911
Customer service indicator	-0.0109	-0.4335	0.4444
Bus frequency indicator	-0.0035	-0.3815	0.3851
Driving license indicator	0.0011	0.1011	-0.1022

4.3 Lahore Metrobus Service Performance Evaluation

The evaluation of the Lahore Metrobus service performance is subjected to analysis of the factors derived from the quality indicators (Eboli and Mazzulla 2011; Xiyuan, 2014). In this study, quantitative and qualitative data is collected from field observations from 11th April to 20th April and the data is then correlated with the standard threshold values given by TCRP or from similar kind of studies and then with the commuters' satisfaction mean values to judge the overall service performance of the Lahore Metrobus.

To evaluate the reliability factor, bus arrival time, breakdown of the bus, safe transaction with the staff and the most important one the bus schedule indicators are correlated with the standard level of service values or from the agency standards. There was no scheduled time to assess the on time arrival of bus at bus station although PMA has planned his schedule for off peak and peak hour's windows with headway of 2 to 3 mints. However, this indicator can be assessed by the upcoming frequency indicator with the same rating (Xiyuan, 2014). Breakdown of the service due to mechanical or non-mechanical fault of the vehicle play vital role to reach on time at bus station and create ambiguity of the service (Eboli and Mazzulla 2011; Xiyuan, 2014). Since 2013, no record was found for the breakdown of the service due to any reason. Satisfying with the ticketing procedure is another quality indicator of reliability and it was assessed by the ticketing methods/ procedures which was found as per standard and modern technologies i-e off board ticketing booth, provision of automatic fare collection machine and smart card (Xiyuan, 2014).

Next, very important indicator of service reliability is the system characteristics in term of information provision provided at each bus stop. Two broad classification of the information are real time information and directional information (Xiyuan, 2014). Real time information includes bus arrival and departure scheduled, traffic condition and next bus arriving time. Directional information consists of bus stop name, station map, direction signs, station and surrounding area map and interchange information (Eboli and Mazzulla 2011; Xiyuan, 2014). Real time information is more important to regular commuters than directional information and is used to evaluate the information performance of the system (Xiyuan, 2014). In this study information provision performance is assessed by the information provided and commuter's easiness to get information and compared with the other competitive mode.

Table 4.8: Information Provision at Each Stop/Terminal

Bus Stop	Information Provision	Performance Assessment
All	a. LED displaying bus arrival time. b. Audible announcement of the arriving bus and station name is provided. c. Route map with feeder route and directional information is also provided.	Lahore Metrobus is providing better service quality information as compare to any other public/private bus system.

Commuter fatalities are collected and retained by the agency for the base year and compared it with the last five years average commuter fatalities. Grading system can be adopted with 0 given to the higher value of commuter fatalities than double average of the last five years. Similarly intermediate grades to the intermediate fatalities and 10 grade is selected when commuter fatalities are less than the average of the last five years (Eboli and Mazzulla 2011; Xiyuan, 2014). Since 2013, no accident or fatalities were recorded for the Lahore Metrobus.

Security indicator is also evaluated in the same manner as safety by the Eboli and Mazzula (2011) i-e register complaints of security for the current year were collected and these complaint were compared with the average value for the last three year values and for Lahore Metrobus no complaint was found. Courtesy of the staff is another quality indicator enlisted in the assurance aspects and there is no threshold value to assess this indictor. However, from the similar kind of studies (Eboli and Mazzula, 2011), in this research, simple question was asked to the commuters about the staff courtesy and commuters respond as extremely satisfied with the staff behavior.

Vehicle maintenance, all time weather waiting area and physical appearance of the system attracts more commuters (Xiyuan, 2014). Daily cleaning is mostly done by the transit agencies operating transit service and overall washing and cleaning is mostly done periodically once in a week, fortnightly or monthly as per agency recommendation. Weekly cleaning and washing is consider as standard value to assess the cleaning of the vehicle. It was observed from the field work that at the completion of the trip, coarse refuse were removed along with the fine dust particles from each the Metrobus and maintenance of the buses is done periodically as per agency recommendations. The site observation reveals that number of shelters and seats are enough to accommodate commuters' even in peak hour at each bus station meeting the recommended design features of the Metrobus however, in summer, all bus stations heat up as sun burns over there during 8:00 to 16:00 hour of the day. Attractive service quality indicators is assessed by the bus appearance, color, cleaning, air-conditioning and other physical facilities such as lights, fan, benches, fare collection machine and ticketing booth provided at bus stop (Xiyuan, 2014).

In view of the previous researches (Tyrinopoulos and Aifadopoulou, 2008; Eboli and Mazzula, 2011), in this research, customer service of the staff is judged by the mystery commuter. Mystery commuter found that all staff is smart, neat and clean, communication with the staff is clear and helping, easy access is available for the ticketing, staff is fully uniformed and enough for the operational purposes. It clearly depicts that agency has commuter interest at heart with higher operational

efficiency. All vehicles were found environmental friendly and fuel efficient maintaining its standards. Travel time saving quality indicator is judged by the travel speed quality indictor of Metrobus in convenience quality aspect.

The availability aspect of Lahore Metrobus performance evaluation include the bus frequency, operating hours and bus fare level quality indicators. To evaluate the bus frequency indicator field data was collected form the site and it can be calculated as average value of the number of arriving buses. While levels of service suggested as a function of the average headway among vehicles expressed in minutes (Transportation Research Board, 2003b). Per person vehicle Km is considered as an indicator of the service frequency and coverage (Friman and Fellesson, 2009). A realistic approach of calculating headway variance is adopted to evaluate the actual perception of the service frequency assessed by the commuter. The methodology is as below

$$C_{vh} = \frac{\text{Std.Headway}}{\text{mean Schedule}-\text{headway}} \quad (4)$$

where,

C_{vh} = Coefficient of variation of headway

Std. Headway = Standard deviation of headway deviation

Mean Schedule – headway = Mean Schedule headway

To get reliable results, data for service frequency is collected at 9 different stations and terminals from 17th April to 19th April in peak hours and off peak hours. Headway, dowel time and clearance time are frequency related terms that is observed for frequency performance evaluation and the threshold value for the headway variation is listed below

Table 4.9: Threshold Value for Level of Service of Headway Variation

LOS	C_{vh}	P(hi > 0.5 h)	Comments
A	0.00-0.21	≤ 1%	Service provided like clockwork
B	0.22-0.30	≤ 10%	Vehicles slightly off headway
C	0.31-0.39	≤ 20%	Vehicles often off headway
D	0.40-0.52	≤ 33%	Irregular headways, with some bunching
E	0.53-0.74	≤ 50%	Frequent bunching
F	≥ 0.75	≥ 50%	Most vehicles bunched

Source: TCRP, 2003

Table 4.10 Statistical Values of Headway

	Mean Schedule Headway	Std. Deviation	Coefficient of variation of Headway	LOS
Peak Hour Headway (sec)	138.47	74.07	0.538	E
Off Peak-hour Headway (sec)	137.72	41.51	0.301	B

The calculation depicts that LOS for the off peak-hour window is “B” while for peak-hour window it is “E”. The off peak-hour window LOS is acceptable on the other hand peak-hour level of service is very low as per expectations. The main reason behind the delay may be the rehabilitation construction work of the corridor although the arriving distribution shows more number of buses during peak hour as compared to off peak-hours. Inferior bus frequency during peak hour doesn’t have negative impact on the mode choice as commuters are still happy to travel in Metrobus although fluctuated bus frequency increases waiting time and impact commuter’s perception of satisfaction. Another indicator to evaluate the bus frequency is bus stop capacity measured in term of dwell time given below

Mean Dwell Time = Average (Peak-hour mean value + off peak-hour mean value)

Mean Dwell Time = 27.834 seconds

Std. Dwell Time = Std. dwell time = 15.97

So, C_v = Coefficient of variance for dwell time

$C_v = (Std.\ dwell\ time)/(mean\ dwell\ time)$ = 0.573

The calculated value of coefficient of variance for dwell time is less than 1 and can be considered as 1 for the Z value given below.

Table 4.11: Z Value Table for Coefficient of Variance

Failure Rate	Z
1.0%	2.330
2.5%	1.960
5.0%	1.645
7.5%	1.440
10.0%	1.280
15.0%	1.040
20.0%	0.840
25.0%	0.675
30.0%	0.525
50.0%	0.000

The Z value is 2.330 for the observed value of C_v. Using the following referred equation, the bus capacity (B_s) can be measure.

$$B_s = \frac{3600\ (\frac{g}{c})}{t_c + t_d\ (\frac{g}{c}) + Z C_v t_d} \quad (5)$$

where, 3600 = seconds in one hour

g/c = green time ratio (the ratio of effective green time to total traffic signal length, equal to 1 for unsignalized and bus facilities

t_c = clearance time in sec

t_d = average mean dowel time in sec

Z = standard normal variable corresponding to desire failure rate; and

C_v = coefficient of variation of dowel time

So, bus capacity B_s is calculated as

$$B_s = \frac{3600}{7+27.834+37.161} = 50.00 \text{ Bus/h}$$

This result shows that Lahore Metrobus has already reached its operational capacity and increasing service frequency is impracticable. TCRP has published for standards to the service time from A to F depending upon the service operating hours.

Table 4.12: LOS for Service Hour

LOS	Service Hours	Comments
A	19-24	Night or "owl" service provided
B	17-18	Late evening serviced provided
C	14-16	Early evening serviced provided
D	12-13	Daytime service provided
E	4-11	Peak hour service only or limited midday service
F	0-3	Very limited or no service

Source: TCRP, 2003

Table 4.13: Operating Hours of Lahore Metrobus

Day Shift	Night Shift	Total Operation Hours	LOS
6:15 – 13:00	13:00-22:00	15 hour 45 mints	C

The Table 4.13 reveals that although the LOS for operating hours is "C" refers as "early evening service provided" but commuters are still extremely satisfied with the service time as it covers almost all the commute time. To evaluate the quality indicator of economic service the commuters recent travel cost was compared with the previously trip cost taken from similar kind of study. A

detailed study on the impact assessment of Lahore Metrobus on commuters and other stakeholders conducted in October 2015, by the Planning and Development Department of Govt. of the Punjab reveals that majority of the commuters were spending 20-50 Pakistani rupees to complete their journey which has now reduced to 20 Pakistani rupees.

The indicator of waiting time at bus stop is related to the on time service frequency indicator and it is given the same LOS as given to the service frequency for peak hour window and off peak hour window (Eboli and Mazzulla 2011; Xiyuan, 2014). The threshold value recommended by the Transit Capacity and Quality of Service Manual for waiting time is maximum 5 mints. To evaluate the performance of travel speed indicator the overall transit travel speed and estimated overall average automobile travel speed comparison is done. The Metrobus speed is observed for peak hour and off peak hour on 20th April.

Table 4.14: Travel Speed Performance Measure of Lahore Metrobus

Metrobus Segment	Operating Hour	Metrobus Travel Speed Km/h	Estimated Automobile Travel Speed Km/h
Elevated Segment	Peak hour	37-47	12-22
	Off Peak hour	33-43	15-25
At Grade Segment	Peak hour	38-48	12-22
	Off Peak hour	36-46	15-25

The Table 4.14 clearly reveals the rapidness of the service as compared to the car/automobile. Short waiting time and higher travel speed paly important role in the mode choice and these are unique characteristics of Metrobus.

The threshold assessing value for the Metrobus recommended by the researchers is 400-500 m while in this scenario most of the commuters have to cover more than 500 m distance to get Metrobus but still commuters are satisfied. To improve the accessibility and attract more commuters PMA has initiative feeder routes. From the field observation it was found that each Metrobus stop provides interchange facility to its end users. It is very difficult to find service quality in real sense as detailed data is required to access actual bus transit service quality.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Synopsis of the Research

This is first study in Pakistan that carried out detailed analysis of Lahore Metrobus. The major focus of this study was to evaluate the overall level of satisfaction of commuters with quality of service provided by the Lahore Metrobus and to carry out service performance evaluation of Lahore Metrobus in terms of established public transit criteria (quality attributes). In present study, an effort has been made to access the service quality provided by the Lahore Metrobus which starting operations in March 2013. Present study developed an enhanced framework to carry out a detailed analysis of commuter satisfaction and quality of service provided by the Lahore Metrobus. Study used both subjective as well as objective scenarios to assimilate commuter satisfaction with existing quality of service of Lahore Metrobus. A comprehensive questionnaire was used to collect data on commuters socio-economic characteristics (gender, age, auto ownership, income level, profession, and number of individuals with a valid driving license in the family), traveling trends (travelling mode, daily commute timings, average distance travelled to get to public transport prior to Metrobus operations, present distance travelled to get the Metrobus, mode to get Metrobus, if longer distances are involved, purpose of commuting by Metrobus, average daily distance travelled by Metrobus, average number of weekly trips in Metrobus) and commuter rating of overall level of satisfaction with Lahore Metrobus (extremely satisfied, satisfied, neutral, unsatisfied and extremely unsatisfied). A total of 400 valid responses collected at all (27) stops of Lahore Metrobus were used for present study. Due to the ordinal nature of the response variable (overall level of satisfaction of commuter with Lahore Metrobus) an ordered probit model has been estimated to study the association of overall level of satisfaction of commuter with Lahore Metrobus with different explanatory variables. Model results revealed that male commuters, commuters from a family size of more than five members, commuters with an average commute time of over 25 minutes before start of Lahore Metrobus

and commuters with higher perception of Lahore Metrobus customer service and frequency are more likely to have higher satisfaction of overall level of service provided by Lahore Metrobus. Study results also revealed that a commuter belonging to a family with more number of individuals having valid driving licenses (a proxy for higher income and education) is less likely to have higher satisfaction of overall level of service provided by Lahore Metrobus, and more likely have lower satisfaction of overall level of service provided by Lahore Metrobus. Marginal effects are computed to see the impact of six significant variables on the intermediate categories of the commuters overall level of satisfaction with Lahore Metrobus.

In second part of present study, service performance evaluation of Lahore Metrobus was carried out in terms of established public transit criteria for the level of service. Quantitative and qualitative data were collected from field and values obtained were compared with recommended standards given by Transit Cooperation Research Program of USA. Seven service performance measure (quality attributes) that were considered in present study include: (1) reliability (2) assurance (3) comfort (4) responsiveness (5) availability (6) convenience and (7) accessibility. The field data for seven quality attributes (such as headway, frequency, physical amenities and travel speed) were collected from different bus stations and the collected information was then compared with the recommended level of service given in the literature for each indicator or by comparing it with the conventional public bus system attributes or agency standards. The overall service performance was then compared with the commuter satisfaction survey to seek the differences between the commuters expectation and the agency overall service performance. The study results revealed that Lahore Metrobus is providing reasonable level of service to the commuters that meet commuters' expectation and recommended standards given by Transit Cooperation Research Program of USA. The seven quality attributes i-e reliability, assurance, comfort, responsiveness, availability, convenience and accessibility are found to be equally satisfied from commuters' point of view and agency provided standards. The results of the present study are expected will help transit agencies, policy makers and planners to improve the Metrobus services in different cities of Pakistan.

5.2 Research findings and Recommendations

Combining the results of subjective analysis and service performance evaluation, the major findings of present research are:

a. Study results revealed that male commuters, commuters from a family size of more than five members, computers with an average commute time of over 25 minutes before start of Lahore Metrobus and commuters with higher perception of Metrobus customer service and frequency are more likely to have higher satisfaction of overall level of service provided by Lahore Metrobus.

b. Study results also revealed that a commuter belonging to a family with more number of individuals having valid driving licenses (a proxy for higher income and education) is less likely to have higher satisfaction of overall level of service provided by Lahore Metrobus, and more likely have lower satisfaction of overall level of service provided by Lahore Metrobus.

c. Commuters are found to be extremely satisfied with the quality aspects of reliability, assurance, comfort and convenience.

d. Commuters are found to be satisfied with the quality aspects of responsiveness, availability and accessibility.

Being the first study in Pakistan that carried out detailed analysis of Lahore Metrobus. The major focus of this study was to evaluate the overall level of satisfaction of commuters with quality of service provided by Lahore Metrobus and to carry out service performance evaluation of Lahore Metrobus in terms of established public transit criteria (quality attributes). In future research efforts detailed data may be collected for each quality attribute and new standards may be established as per local conditions. Also transit providers/ operators should incorporate female, handicap, children and elder age commuters in their design. Many of the quality indictors discussed in this research required detail study on each quality aspect for example, to investigate the travel time saving from the induction of Metrobus requires detail study to compare travel time before and after the introduction of service.

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ANNEXTURE "A"

COMMUTER SATISFACTION SURVEY QUESTIONNAIRE

Government of Pakistan has started Bus Rapid Transit System (BRTS) / Metrobus system to resolve the road traffic congestion problems of common man in mega cities like Lahore, Multan, Karachi, Faisalabad etc. I am doing my Master degree of transportation engineering from National University of Sciences and Technology (NUST), Islamabad. My master thesis is on "An analysis of Lahore Metrobus Service". For my research I have developed questionnaire survey and I require your valuable feedback.

General Information of the Commuter:

1. What is your Gender: Male ☐ Female ☐

2. Age: _____

3. Do you own a Car? Yes ☐ No ☐

4. Do you own a Motorcycle? Yes ☐ No ☐

5. Do you own a Bicycle? Yes ☐ No ☐

6. What is your Monthly Income?

   (i) No Income (ii) 10,000-20,000 (iii) 20,000-30,000 (iv) 30,000-40,000 (v) 40,000-50,000 (vi) 50,000-60,000 (vii) Above 60,000

7. What is your Profession?

   (i) Student (ii) Teacher (iii) Engineer (iv) Doctor (v) Labor (vi) Merchant (vii) Farmer (viii) Carpenter (ix) Painter (x) Mason (xi) Job Holder (xii) Govt. Servant (xiii) others

8. How many family members do you have?

   (i) 1-2 (ii) 2-3 (iii) 3-4 (iv) 4-5 (v) 5-6 (vi) 6-7 (vii) 7-8 (viii) 8-9 (ix) 9-10 (x) More than 10

9. Are you married? Yes ☐ No ☐

10. Do you live in a combine family system? Yes ☐ No ☐

11. How many individual in your family have driving licensed?

    (i) 0-1 (ii) 1-2 (iii) 2-3 (iv) More than 3

12. Where do you live? _____

Travel Characteristics before Metrobus:

1. What was your mean of travel before Metrobus?

   (i) By local bus (ii) By van (iii) By own car (iv) By own motorcycle (v) By own bicycle (vi) by rickshaw (vii) Shuttle bus (viii) Private car/taxi (ix) Others

2. What was your travelling time before Metrobus?

   (i) 5-10 mints (ii) 10-15 mints (iii) 15-20 mints (iv) 20-25 mints (v) 25-30 mints (vi) 30-35 mints (vii) 35-40 mints (viii) 40-45 mints (ix) 45-50 mints (x) 50-55 mints (xi) 55-60 mints (xii) More than 1 hour

3. How much distance you had to travel to get public transport?

   (i) 100-200 m (ii) 200-300 m (iii) 300-400 m (iv) 400-500 m (v) 500-600 m (vi) 600-700 m (vii) 700-800 m (viii) 800-900 m (ix) 900-1,000 m (x) More than 1km

General Travel Characteristics of Commuter:

1. How much distance you have to travel to get Metrobus?

   (i) 100-200 m (ii) 200-300 m (iii) 300-400 m (iv) 400-500 m
   (v) 500-600 m (vi) 600-700 m (vii) 700-800 m (viii) 800-900 m
   (ix) 900-1,000 m (x) More than 1km

2. What is your mode of travel to get Metrobus?

   (i) By local Bus (ii) By van (iii) By own car (iv) By own motorcycle
   (v) By own bicycle (vi) By rickshaw (vii) Shuttle bus
   (viii) Private car/taxi (ix) Walking (x) Others

3. What is the purpose of your travel?

   (i) School (ii) College (iii) University (iv) Office (v) Shop
   (vi) Work Station (vii) Shopping (viii) Other purpose

4. What is your Total Daily Travelled Distance?

   (i) 1km-5km (ii) 5km-10km (iii) 10km-15km (iv) 15km-20km
   (v) 20km-25km (vi) 25km-30km (vii) 30km-35km (viii) 35km-40km
   (ix) 40km-45km (x) 45km-50km (xi) More than 50 km

5. What is your Total Daily Travelled Distance in Metrobus?

   (i) 1km-5km (ii) 5km-10km (iii) 10km-15km (iv) 15km-20km
   (v) 20km-25km (vi) 25km-30km

6. How many weekly Trips do you made in Metrobus?

   (i) 1-2 (ii) 2-3 (iii) 3-4 (iv) 4-5 (v) 5-6 (vi) 6-7 (vii) 7-8 (viii) 8-9
   (ix) 9-10

7. What is your daily Travel Time in Metrobus?

   (i) 5-10 mints (ii) 10-15 mints (iii) 15-20 mints (iv) 20-25 mints (v) 25-30 mints (vi) 30-35 mints (vii) 35-40 mints (viii) 40-45 mints (ix) 45-50 mints (x) 50-55 mints (xi) 55-60 mints (xii) More than 1 hour

Question about Metrobus Service Quality:

1. Do you think that Metrobus always arrive on time at bus terminal? Yes ☐ No ☐

2. Have you ever experienced breakdown of Metrobus on road? Yes ☐ No ☐

3. Do you think staff shows courtesy? Yes ☐ No ☐

4. Are you satisfied with ticketing procedure? Yes ☐ No ☐

5. Do you think that transaction with Metrobus staff is safe? Yes ☐ No ☐

6. Are you satisfied with the security arrangement inside Metrobus corridor? Yes ☐ No ☐

7. What is your usual waiting time at waiting hall?

   (i) 0-5 mints (ii) 5-10 mints (iii) 10-15 mints (iv) 15-20 mints (v) 20-25 mints (vi) 25-30 mints (vii) 30-35 mints (viii) 35-40 mints (ix) 40-45 mints (x) 45-50 mint (xi) 50-55 mints (xii) 55-60 mints (xiii) More than 1 hour

8. How much you are satisfied with the present Metrobus?

   (i) Extremely satisfied (ii) Satisfied (iii) Neutral (iv) Unsatisfied (v) Extremely unsatisfied

9. Do you think that Metrobus staff is sufficient for operation purposes? Yes ☐ No ☐

10. Do you follow the bus schedule or casually travel to Metrobus terminal?

    _____

11. Do you think that Metrobus is saving commute time? Yes ☐ No ☐

12. Do you think that Metrobus is attractive service? Yes ☐ No ☐

13. Do you think that Metrobus provide interchange bus facility? Yes ☐ No ☐

14. Do you think that Metrobus is efficient service?

    (i) Extremely satisfied (ii) Satisfied (iii) Neutral (iv) Unsatisfied

    (v) Extremely unsatisfied

15. What is customer service of Metrobus staff?

    (i) Excellent (ii) Good (iii) Satisfactory (iv) Average (v) Low

16. Do you think that Metrobus terminals have enough all weather waiting area? Yes ☐ No ☐

17. Do you think that Metrobuses are well maintained? Yes ☐ No ☐

18. Do you think that Metrobus operating hours are suitable? Yes ☐ No ☐

19. Are you satisfied with the frequency of Metrobuses?

    (i) Extremely satisfied (ii) Satisfied (iii) Neutral (iv) Unsatisfied

    (v) Extremely unsatisfied

20. Do you think that Metrobus is economic service? Yes ☐ No ☐