Potential of Park and Ride Scheme at BRT Peshawar

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THESIS ACCEPTANCE CERTIFICATE

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DEDICATED

TO

PARENTS, SIBLINGS,

TEACHERS AND FRIENDS

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In the name of Almighty ALLAH, the most Merciful, the Beneficent. All praise is only for ALLAH who is our Creator and always planned the best for us. I am grateful to Almighty ALLAH for His countless blessings and mercy bestowed upon me through the difficulties of life and I seek His guidance, and pray to Him for blessings and ease throughout this life and the life to come.

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Talha Haroon Khan

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List of Abbreviations

BRT -	Bus Rapid Transit
SP -	Stated Preference
RTA -	Road Traffic Accidents
RP -	Revealed Preference
MMP-	Mott Mac Donald Pakistan
PC -	Passenger Cars
MC -	Motorcyclists
OVTT-	Out of Vehicle Travel Time
PKR -	Pakistani Rupee

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Abstract

Bus Rapid Transit (BRT) is considered as a vital component of a transportation system as it offers a lower investment cost, flexible implementation and a more advanced urban system. Along with BRT, Park and Ride scheme offers an efficient solution to modern-day traffic complications with a proficient urban infrastructure and a robust economy. This study evaluated the potential of modal shift from private vehicles to BRT in Peshawar as it provided an increased level of service to the commuters. Similarly, the potential of park and ride scheme at BRT Peshawar was assessed for the provision of parking lots at particular stations. Multinomial regression was used to assess the data obtained by the Stated Preference (SP) survey. The three main areas that were considered regarding public transport users were socioeconomic, trip and parking characteristics. It was observed that travel time, out of vehicle travel time and travel cost along with some socioeconomic factors including age, education, and income level affect the mode choice and parking usage. The study revealed that still most of the people will prefer private vehicles for commuting purposes. It also revealed that middle-class people are more likely to utilize the facility. The modal shift and parking usage can be augmented by providing subsidies, improving the level of service and implementation of policies that restrain car usage.

CHAPTER 1

1 INTRODUCTION

1.1 Background

Transportation is inextricably linked with economic development, social progress and the qualitative life of an urban system.[1] For improving these parameters, the road infrastructure of a city always needs to be planned for the betterment of all aspects of a system.[2] One of the major components of the urban transportation system is passengers that have increased throughout the world over the past few decades due to an increase in the population, urban migration and an increase in economic activities. This has increased the ridership in the cities but the current system is incapable of holding the increased volumes of passengers.[3] The existing transport system has caused unnecessary delays, salvage costs, high energy consumption and more specifically has augmented RTA’s due to its poor condition.[4]

In Pakistan, the traffic system modifications are desperately needed to make daily travel easier and faster. The former system has lost the capability to handle the emerging traffic mass. Peshawar, the capital of Khyber Pakhtunkhwa, comprising of about 1275 km^2 and a population of 2,133,000 is experiencing the same grim situation of growing traffic. With increasing economic activities and uncontrollable population growth, efficient mobility in the city has become problematic. The traffic system in the city is highly heterogeneous consisting of a wide variety of traffic e.g. private vehicles, taxis, rickshaws, buses, wagons, motorcycles and cycles. People usually preferred buses and wagons as a cheaper mean of commuting but urbanization in the near past has shifted the mode towards private vehicles. Further due to an increase in wealth profile, cars and motorcycles have become affordable and passengers are preferring private over public vehicles for increased mobility, safety, time-saving and comfort purposes.[5] Moreover, people are also reluctant to travel via public transport due to status issues.[6] Regarding public transport, buses and wagons are operating at a speed of 11km/hr which is far below than 25km/hr (standard operating speed for public transport).[7] The reason for this reduction of speed is the difficulty of large vehicles to maneuver through congested traffic. Whereas taxis were charging double fares and people were not preferring this mode as well.[8] Thus, all these issues have caused a high passenger car and motorcycle share. For this high volume of traffic, there are no parking facilities which have promoted curb-side parking and hence led to the congestion.[9] The existing highly congested traffic has deteriorated air quality, increased noise and vibrations and emission of maximum toxic gases.[10] This is an alarming situation for the city's public transport.

Therefore, an improved system with a dedicated bus lane and special parking lots was inevitable to save the time and money of the citizens. Hence, Bus Rapid Transit (BRT) systems have gained worldwide popularity as a cost-effective alternative and best solution to address all the aforementioned issues.[2,11,12] It will reduce the accidents, congestion, fuel consumption and emission of toxic gases in the city.[13,14]

1.2 Problem Statement

Peshawar was experiencing severe traffic congestions and travel delays in the near past due to increase in private car ownership. The increasing demand of vehicles caused needless interruptions to overall traffic system. Moreover, due to scasrcity of parking lots in the hubs, commuters had to manuever through heavy traffic to reach to their destination. Studying of travel behavior and modal preference of commuters is essential for understanding the timings and various modes used for travel which in turn help in the understanding of type and number of vehicles in a traffic stream. Similarly, perceiving the traveler's choice for parking helps in estimating parking demand in the conurbation.

1.3 Research Objectives

This study aims to find the probable modal shift of private vehicles (cars and motorcycles) users to BRT and the potential of Park and Ride Scheme at BRT. The study is based on the stated preference (SP) approach used for surveying on the particular stations. The modal split models were developed to predict the choices of passenger car users and motorcycle users to use BRT. The parking spaces have been estimated for the commuters intending to utilize Park and Ride facility.

This study aimed at achieving the following objectives:

- To find the modal shift of passengers from private vehicles (car and motorcycles) to BRT.
- To identify the parking spaces for Park and Ride Scheme at stations at BRT Peshawar.

1.4 Organization of thesis

This thesis is composed of five chapters and the detail of each chapter is discussed below.
Chapter 1: Includes the background of the study, research objectives and problem statement.
Chapter 2: It conscripted the review of previous studies regarding modal shift and parking analysis. It includes literature review on different approaches applicabe to estimate the modal shift and parking demand nationally and internationally.
Chapter 3: This chapter explains the methodology adopted and each step of the methodology is explained in this chapter. The analysis is also explained in this chapter.

Chapter 4: It includes the results and discussion on the developed models.
Chapter 5: It includes the applications of developed models and conclusion with future recommendations to increase ridership on BRT.

CHAPTER 2

2 LITERATURE REVIEW

2.1 General

This chapter contains the literature review and the associated theory behind the mode choice modeling of student commuters which have been carried out in various countries. The details of the survey conducted and the questions asked of the respondents, the methodology used, and type of model developed and a summary of the results of past literature are also discussed.

One of the major components of the urban transportation system is passengers that have increased throughout the world over the past few decades due to an increase in the population, urban migration and an increase in economic activities. This has increased the ridership in the cities but the current system is incapable of holding the increased volumes of passengers. Largely dense cities desperately need improved and expanded public transport service and not personal vehicles. This requires both an increase in quantity as well as the quality of bus transport services and effective application of demand management as well as supply-side management measures. One way of achieving this goal is the provision of reserved bus lanes on major urban roads. The provision of exclusive road space, thus, will enhance the level of service of buses and this may also result in a shift of some of the personal vehicle users to buses. It was found that the factors which influence the intentions of the single-occupant commuters to switch to buses and carpools and suggested operating policies consistent with the intent to encourage the use of high-occupancy vehicles. They found that in buses, convenience is the most important variable associated to shift. They also found that perceptions of carpool comfort do not appear to be important, rather, perceptions of carpool schedule flexibility, cost, safety and a short wait in traffic were found to be the prime factors associated with the potential shift to carpool.

Another study identified different policy actions to reduce car use for different types of trips and the actions that are required to meet the travel needs that the car currently fulfills. The evidence on why people used their cars for a set of real short trips is considered in terms of several dimensions including age, gender, and trip purpose. This is followed by a discussion of the alternative modes to the car that drivers say that they might adopt and the factors that would make them consider switching to these alternatives. [3]

2.2 Existing Transport System

The existing transport system has caused unnecessary delays, salvage costs, high energy consumption and more specifically has augmented RTA's due to its poor condition. Road-based passenger mobility has increased tremendously over the years. The rapid increase in motorized mobility during the last two decades or so is primarily due to an increase in urban population as a result of both internal growth and migration from rural areas and small towns. In the absence of an adequate and efficient bus transit system, the potential bus users currently use private transport modes mainly motorized two-wheelers and, to some extent, cars. Also, some of them resort to using another para-transit mode called auto-rickshaws. Thus, a large number of private and para-transit vehicles have entered the market to meet travel demand. As the available road space is limited, the proliferation of these vehicles results in severe congestion, inordinate delay, high-energy consumption, and intense pollution of the environment.

The vehicles occupy lateral position on the road, depending on the availability of road space, at a given instant of time without any lane discipline and it is nearly impossible to impose lane discipline under such conditions. Under the said heterogeneous traffic flow conditions, the buses, being relatively larger vehicles, find it difficult to maneuver through the mixed traffic and are subject to frequent acceleration and deceleration leading to lower speed and discomfort to both the driver and passengers.

This also results in enormous delays and uncertainty to bus passengers and consequently, the level of service of buses gets reduced considerably making the bus, a less attractive mode of transport. Most of the cities desperately need improved and expanded public transport service and not personal vehicles. This requires both an increase in quantity as well as the quality of bus transport service and effective application of demand as well as supply-side management measures. This goal can be attained by encouraging bus transport by assigning priority to it.

One of the common bus preferential treatments is the provision of reserved bus lanes on major urban roads to facilitate faster movement of buses, which will make the mode more attractive. The provision of exclusive road space, thus, will enhance the level of service of buses and this may also result in the shift of some of the personal vehicle users to buses. This paper is concerned with the study of the possible shift of car users to the bus because of the increased level of service of the bus, after the provision of exclusive bus lanes. [4]

In Pakistan, the traffic system modifications are desperately needed to make daily travel easier and faster. The former system has lost the capability to handle the emerging traffic mass. Peshawar, the capital of Khyber Pakhtunkhwa, comprising of about 1275 km2 and a population of 2,133,000 is experiencing the same grim situation of growing traffic. With increasing economic activities and uncontrollable population growth, efficient mobility in the city has become problematic. The traffic system in the city is highly heterogeneous consisting of a wide variety of traffic e.g. private vehicles, taxis, rickshaws, buses, wagons, motorcycles and cycles. People usually preferred buses and wagons as a cheaper mean of commuting but urbanization in the near past has shifted the mode towards private vehicles. Further due to an increase in wealth profile, cars and motorcycles have become affordable and passengers are preferring private over public vehicles for increased mobility, safety, time-saving and comfort purposes.The rapidly increased demand for public transport is an inevitable issue confronted by the local public of the city nowadays. Developed countries have an organized system and modes of local transport for the public that are kept in mind over which concrete steps are taken to study various modes of transport. [1] Major causes of traffic congestion in Peshawar are roadside encroachments, inappropriate car parking due to the unavailability of parking lots and increase in private cars in about a decade.There are about 28,000 rickshaws in the city that are a major factor of environmental pollution in the region.

Improvements in public transport are probable if a dedicated lane is planned for the mobility of public transport like BRT. This will provide comfort to the passengers as well as will release the onus on the roads for other private vehicles. Hence the main goal to be achieved is the cost-effective mode of transport and origin to destination time optimization of public transport in Peshawar. [5] Moreover, people are also reluctant to travel via public transport due to status issues. Many case studies have shown that BRT can be a cost-effective way to provide a high-performance transport service.

Besides, BRT is recommended to realize the low carbon society target for Asian developing cities since BRT would shift private vehicle users to a transport sector that emits lower CO_2. Many previous studies have proposed integrated strategies with BRT systems to cope with urban sprawl in developing Asian cities. Due to the poor service of existing public transport and cheap motorcycle use, many developing Asian cities have a very high private vehicle share, especially for motorcycles. [13] Thus, it is very challenging to encourage a modal shift from motorcycle to BRT. Previously, some studies proposed policies and planning of bus systems in motorcycle dominated communities.

It is not easy to achieve the high modal shift to BRT in developing countries where an increase in wealth profile is making private vehicles a more affordable means of transport, as well as conferring elements of status causing a high passenger car (PC) and motorcycle (MC) share. Some passenger car users from high-income families prefer their existing mode because of comfort, privacy, and status considerations. The planning of BRT is intended to increase the attractiveness of bus transport and affect modal shift from private vehicles.

Previously, the relative passenger attractiveness of BRT systems compared to other transit modes by using a trip attribute approach was examined. The study examined how passengers valued trip attributes for on-street bus, BRT, and light rail and heavy rail systems in passenger behavior researches conducted in many countries. The lower costs for BRT systems compared to rail may be used to claim cost-effectiveness advantages for BRT. [6]

Regarding public transport, buses and wagons are operating at a speed of 11km/hr which is far below than 25km/hr (standard operating speed for public transport). The reason for this reduction of speed is the difficulty of large vehicles to maneuver through congested traffic. Whereas taxis were charging double fares and people were not preferring this mode as well.An efficient and cost-effective public transport system is essential for the daily mobility of people.

BRT system is recognized as amongst the most effective solutions in providing high-quality transit services on a cost-effective basis to urban areas both in the developed and developing world. BRT is a high-quality, customer-orientated transit that delivers fast, comfortable and cost-effective urban mobility. BRT system at a corridor may be achieved by considering improvements to the existing infrastructure, vehicles and by proper scheduling. The improvements can be made in existing infrastructure, vehicles, riding quality, increasing the capacity and proper scheduling. [7]

There are 4 types of vehicles operating as public transport vehicles in Peshawar. The biggest capacity is Minibus, which also has two sub-types: Mazda minibus and Bedford buses. Both sub-types have a similar size of approximately 8 meters long with a capacity of 41 passengers inside the bus. The second vehicle type is the Ford wagon, with a capacity of 15 passengers.In addition to the above, the Suzuki vans start to gain some public transport market shares, with at least 14 routes plying on Peshawar road. Small people carrier called Qing qi – named after the Pak-Chinese based motorcycle brand used as the vehicle, are also operating in Peshawar and relatively popular for short-distance trips. [8]

Thus, all these issues have caused a high passenger car and motorcycle share. For this high volume of traffic, there are no parking facilities which have promoted curb-side parking and hence led to the congestion. This unprecedented growth has led to urban sprawl, dependency on motorized transport, and increased parking space demands throughout the city limits. Parking on the roads and sidewalks has resulted in a reduction in traffic capacity, traffic speed variation, accidents and disruption in the smooth flow of traffic.

Though the government has adopted measures in the past to streamline roadside parking activities, these efforts have proved counter-productive. With the rapid increase in private transport modes, the menace of curbside parking has clung to several metropolitan cities across the world. To seriously cope with this situation, many cities have employed several techniques and strategies to manage curbside parking using geometry, timing, pricing, technology, and enforcement. [9] The existing highly congested traffic has deteriorated air quality, increased noise and vibrations and emission of maximum toxic gases which was an alarming situation for the city's public transport.

Therefore, an improved system with a dedicated bus lane and special parking lots was inevitable to save the time and money of the citizens. Hence, Bus Rapid Transit (BRT) systems have gained worldwide popularity as a cost-effective alternative and best solution to address all the aforementioned issues.[2, 11, 12] It will reduce the accidents, congestion, fuel consumption and emission of toxic gases in the city. Further, it will help in improving the environmental conditions of the road. The planning of BRT is intended to increase the attractiveness of bus transport and affect modal shift from private vehicles.

2.3 Remedies to Mitigate Congestion

Since long, it has been a concern of every government to get people shifted from personal vehicles to public transport. The out of date transport systems are a threat to the economies and environments of the societies. Currently, people are not willing to shift from their private vehicles towards public transport because the existing public transport systems are deprived of the basic desires people are expecting. After a series of studies, it has been determined that Bus Rapid Transit is the best probable solution to the prevailing traffic conditions. Bus Rapid Transit is worldly adopted as a fruitful measure for urbanized areas to provide people with an efficient and safe mode of transportation.

In previous studies, it has been observed that the modal shift from personal vehicles to BRT occurs as BRT gains comparatively more advantages than private vehicles. This advantage may be in the form of cost, capacity, flexibility, safety, comfort, and reliability. The improvement of these factors is key to attract more commuters out of their vehicles. A modal shift occurs when one mode gains a comparative advantage in a travel market over another. The comparative advantage can take various forms, such as costs, capacity, time, flexibility, or reliability. Depending on the kind of passengers traveling and their circumstances (socio-economic characteristics, purpose of trip, etc.), the relative importance of each of these factors vary.

It is necessary to improve the performances of a traffic network which can be one of the basic tasks of transport planning. The development of new services such as Park & Ride systems, individualized public transport services as well as the creation of transport plans (car-pool, car-share) can significantly reduce the number of individual vehicles entering the urban area, thus reducing congestion levels and improving traffic flow performances. One of the possible solutions is to develop integrated transport strategies and create conditions needed for the new services to be deployed (Park & Ride systems, carpool/car-share plans, individual public transport services, congestion charging policy, demand-responsive services, etc.) The main goal of these strategies is to influence traffic behavior to achieve a modal shift towards cleaner and energy-efficient modes (public transport, cycling traffic, walking, etc.).To do this, certain data collection process on the current state of traffic system must be undertaken. [10, 13, 14]

2.4 Mode Choice Modeling

The factors, which influence the intentions of the single-occupant commuters to switch to buses and carpools and suggested operating policies consistent with the intent to encourage the use of high-occupancy vehicles. They found that in buses, convenience is the most important variable associated with the shift intention. They also found that perceptions of carpool comfort do not appear to be important, rather, perceptions of carpool schedule flexibility, cost, safety, and a short wait in traffic were found to be the prime factors associated with potential shift to carpool. On the basis of these modal characteristics and the different service strategies offered, peoples' perception and their probability of selecting the proposed system are predicted. The results show a wide range of peoples' perception and their probability of choosing the better service. Binary Logit models were developed involving car and bus and car and train. The most important variables, found likely to encourage the use of public transport, were as follows: reduced travel time, walking distance to public transport stations, and subsidized fare.

A study revealed the citizens' perceptions of the bus condition, as a determining factor for their choice of bus transportation, and developed a binary Logit model to analyze traveler choice behavior. The result of this study shows that citizens' perceptions of the three chosen bus-transit condition aspects (fare, convenience, and frequency) have a significant influence on public-transport-mode choice. Discrete choice models are developed to identify the role that socioeconomic and demographic characteristics of households have on the propensity to the use of car and public transport.

A paper identified different policy actions to reduce car use for different types of trips and the actions that are required to meet the travel needs that the car currently fulfils. Then, the evidence on why people used their cars for a set of real. The analysis of results from the surveys shows that, "improving public transport" is the specific action, which drivers say, is most likely to attract them out of their cars. [4] Moreover, the mode choice also depends upon the socio-economic characteristics of the commuters and the purpose of the trip. The shift from personal vehicles is associated with system performance, personal perceptions, and local circumstances. Traffic congestion is one of the most contentious urban issues facing policymakers today, and the associated costs can be high. It is in this context that bus priority measures have become one of the major instruments used by policymakers to affect modal shift. It is seen to include bus services that are, at a minimum, faster than traditional “local bus” services and that, at a maximum, include grade-separated bus operations.

It was also assessed that customer satisfaction with quality improvements in public transport. A trip attribute approach was adopted to compare the passenger attractions of BRT relative to other public transport modes and finds that rail holds an advantage over normal on-street bus services but that, in general, no such advantage exists over BRT. They investigated service attributes related to bus priority. Comfort and travel time attributes were seen amongst the most important by existing users of the service. In the context of experimentation connecting consumer attitudes to behaviour, and outlined recent transportation-related attitudinal data applications. However, none of these studies investigates attitudes of catchment area respondents to bus priority attributes. [15]

Access time and operational conditions of public transport have also affected the mode choice. Increase in the number of personal vehicles creates problems such as traffic congestion, increase in number of accidents, parking problems and environmental pollution. Obviously, it is not possible to increase the roadway facilities such as carriageway width in proportion to the increases in traffic in the city. [1] The growing population, land development, congestion, and the associated pollution has convinced people to shift towards public transport and hence BRT. Similarly, schedule flexibility and cycle time of buses have convinced people on the selection of public transport (BRT) for travel purposes.

Therefore, BRT may (or may not) involve the use of exclusive rights-of-way, may (or may not) involve the use of transit signal priority, and may (or may not) benefit from the use of automated vehicle identification (AVI) and/or location technologies. Regardless of the mix of features present, BRT projects are designed to operate much faster and more reliably than conventional bus transit systems . In a majority of instances where political necessity warrants high-capacity transit consideration (i.e., light or heavy rail), exclusive right-of-way may be unattainable (at least within any given project’s available budget).The use of computer technology to increase the sophistication of traffic control devices, improve fleet management, and provide real-time passenger information has dramatically broadened the potential for optimizing bus operations, reducing operating costs, and adding value to the travel time spent "ridesharing" in transit vehicles. Bus service usually competes for commuters and other customers at a significant operating disadvantage when compared to the automobile. Stopping frequently and having to maneuver in and out of the mainstream traffic flow (which is usually occupied by drivers with little incentive to let them in), traditional intra urban bus services are perceived by the public as being too "slow and unreliable" for traveling consideration.

On the other hand, BRT projects can generally be completed in phases as funding and opportunity permit; because of service flexibility, even the core segment can be left for last. This incremental development provides an opportunity to show progress much earlier than with most rail projects. Grade separation and crossing protection from street traffic are usually provided in either instance. One of the biggest limitations of rail service versus bus service is the high cost of distributing passengers to their ultimate destinations.

In addition, the cost of maintenance for lightly used branch lines is only marginally less than that for heavily used mainlines, a fact not lost on commuter or freight railroad management. Rail transit operators rely on feeder bus services to provide this distribution, but time and financial transfer penalties dampen the attractiveness of the multiple-seat ride and foster the proliferation of park-and-ride lots. BRT operations can overcome some transfer problems by operating branch service on local streets directly to the mainline. In general, densely developed linear corridors with readily available exclusive rights-of-way are better suited for rail rapid transit than BRT.

In practice, it would appear that the effectiveness of BRT applications using advanced signal in mixed traffic exceeds the potential effectiveness for light rail transit (LRT) operating in the same environment. In these corridors, operating in mixed traffic may be inevitable, and mixed-traffic operation is within the domain of BRT. Advances in automatic vehicle location (AVL) and traffic signal technology offer opportunities to reduce traffic overflowing into residential areas from the major arterial roads.

To better compete with auto vehicles for mode share, transit services should adhere to scheduled performance parameters—whether by headways or by time point—and not run ahead of schedule. In the absence of exclusive rights-of-way, transit operators are subject to the same street traffic conditions as auto drivers. While auto drivers often have the ability to adjust to delays caused by nonrecurring events (e.g., traffic accidents, fire reroutes, etc.) through route deviation, transit operators are rarely afforded that opportunity. The implementation of bus signal priority offers an opportunity for transit operators to maintain both competitive operating speeds and on-time performance.

However, signal priority alone does not guarantee on-time performance and schedule adherence. To implement these features, transit signal priority needs to be provided on a more selective basis and only activated when the transit vehicle is operating behind schedule. Another key element to successfully implementing BRT is marketing. The purpose of marketing is to distinguish BRT from conventional bus service. The marketing for and branding of BRT appears to influence how the public, the press, and elected officials will respond to the service and future flexibility in establishing price points. In addition, size and appearance apparently does matter for BRT.

Beyond the fact that the BRT program is expected to provide a faster, more highly reliable trip than conventional bus service, there are practical operational and political reasons to emphasize BRT's greater comfort and advanced features with the public. The difficulty encountered in conveying these service aspects largely reflects the minimal physical differentiation between service types when operating in mixed traffic. The public transit industry has been collaborating with the FTA in an effort to define BRT characteristics.

BRT vehicles can operate practically in any traffic environment, but the provision of limited or exclusive use can give BRT its speed, reliability, and identity. BRT running ways can be operated almost anywhere: on abandoned rail lines, within a highway median, or on city streets. BRT systems typically offer fast and efficient fare collection systems to speed boarding and increase convenience. BRT systems generally rely on advanced digital technologies to improve customer convenience, speed, reliability, and safety. Clearly, the array of features identified above need not be unique to BRT. However, because they are not yet widely available in conventional bus services, the introduction of several elements can significantly set apart BRT from other operations in a transit system .[16]

2.5 Factors Affecting Mode Choice

It was found that in developing countries apart from travel time and travel cost, age, gender, education, car ownership, household size, income level and distance from home to public transport also influence the individual's mode choice. However, the reduction of out of vehicle travel time (OVTT) increases the modal share of public transport.[17] The people at the walking distance from the facility mostly preferred this mode than to use their private vehicles.[10] People usually preferred to access the terminal station than to transfer stations. Moreover, improving the quality of the environment around stations encourages and attracts more passengers.

Both descriptive analysis and regression analysis on the commuter survey are conducted to reveal the association. Descriptive analysis indicates that the walk access distance in the morning peak is longer than that in the afternoon peak. Young commuters walk farther to access to stations than children and older people. The walk access distance decreases with increasing household income. Regression analysis, in particular, on the association between walk access distance and station context suggests that commuters walk farther to reach a terminal station but walk a shorter distance to arrive at a transfer station than to a typical station.[18] The feeder services provided along the BRT route have provided a pick and drop option for the users and the walking distance was reduced which has increased the daily ridership of buses. Transport trip generation models are considered with an aim to improve the accuracy of transport generated trips. Information systems are reviewed, and “smart growth” criteria that could affect the accuracy of trip generation models are also identified.[19]

Currently, in Asian developing countries, cars and motorcycles share are maximum due to its convenience. Therefore, an improved public transport system with exclusive and priority lanes needs to be developed on high-density corridors or on the routes where the existing system is serving poorly. In summary, the proportions of modal shift from private vehicle users to BRT have a very wide range depending on various factors. It was suggested that the BRT system should be developed on high density corridors, or on corridors that are poorly served by existing buses. This system would be a high quality bus system with rapid transit based operation (exclusive and priority lane with high frequency and reliability). Even if this infrastructure and service is developed, it is still uncertain to achieve a high modal shift to BRT, particularly in a private vehicle dominated community.[6] Similarly, access for bicyclists, motorcyclists and car users' along with their parking spaces needs to be considered. Motorcyclists and bicyclists preferred public transport where there was a subsidized fare. [20] It was observed that frequent stop and go public transport service needs to be revised to mitigate congestion issues in the city. The public transport should be non-signalized or automated vehicle identification should be used to make it a non-stop service.[16]

2.6 Modal Shift in Similar Schemes

Different policy actions are required to reduce car usage i.e. taxes for entering the cities or hubs and arrangements to increase operational costs of private vehicles inside the city. Similarly, increasing the procurement amount of vehicles increases bus ridership. In high density commercial areas of the city where vacant land is non-existent, the practice of constructing multi storey parking plazas has been a norm. Unlike already discussed practices, small and large-scale parking lots are common in various planned commercial areas in Lahore. These parking lots are usually off-street, open parking areas, which not only provide parking spaces, but also include other related features like landscaping, parking islands, and vehicle circulation spaces (aisle and access lanes).[9]
In the same way, some other measures have also been taken to restrict the usage of personal vehicles and force people to travel via public transport i.e. BRT. It includes the taxes for entering the city, increased fare for parking at parking spaces and heavy fines for parking at non-authorized spaces. The station center co-ordinates, dimensions, access type as well as the expected peak hour bus frequency data per station is important. Off-corridor bus stops are required outside the BRT corridor segments, so that the BRT buses can pick up passengers.[21]

One of the probable solutions is to develop integrated policies and generate circumstances for the new services to be deployed (Park and Ride, congestion charging policy and demand-responsive services, etc.). The main objective of these policies is to create an impact on traffic behavior to attain a modal shift towards more sophisticated and energy-efficient modes e.g. BRT, cycling, and walking, etc.[10] The best approach to modal split is to pose it as a consumer choice and utilize logit models to explain it.[1] Additionally, public transport accessibility, employment ratio, and walking distances affect the calculations of a transportation model.[19] It has been suggested that personal vehicle users should be addressed in such studies to find the modal shift from private cars and motorcycles towards BRT.[15] A study conducted in Jakarta, Indonesia found that the modal shift towards BRT from personal vehicles in its first month of operation was 20%.[22] The shift from private cars to BRT in Los Angeles was 18%.[23] The shift towards BRT from private cars in Beijing was 12.4%.[24]

2.7 Parking Studies

With the growing private car ownership, a major concern for authorities is the provision of parking lots in the city hubs to decrease on-street parking and traffic volume on the roads. Decision makers are confused regarding the locations of parking because of the non-availability of space inside the hubs. Since parking is a basic need for transportation infrastructure but in the current promptly emerging urban traffic, the environment is getting worse with the non-provision of parking spaces. Car owners park their vehicles on the roadside due to the absence of parking lots which causes traffic blockage. This disordered parking causes inconvenience to the daily travelers and influences the living standards of residents.

According to location, there are on-road and off-street parking lots. In on-road parking lots, vehicles are parked within the red lines of roads. On-road can be further divided into road and road-side parking lots. Off-street parking lots refer to special parking lots, parking garage or parking building outside the red line. Off-street parking lots can also be divided into outdoor parking lots and indoor parking lots. According to service targets, there are public, accessorial and private parking lots. According to types of construction, there are parking structure, over-ground parking lots and under-ground parking lots.According to managing patterns, there are free, limited time (free) and charging parking lots.

Layout of parking lots and parking modes should be chosen based on direct economic benefits, social benefits, indirect economic benefits, environmental effect and sustainability etc. Comprehensive benefit should be primarily concerned. The layout of parking lots should meet parking needs. Select location and arrange layout properly. Serving radius should be within 300m from the service centre. [25]

It is vital to minimize traffic congestions, accidents and pollution through proper parking management. Park and ride scheme is an efficient service that may address the aforementioned issues and attract more riders who may not have otherwise opted for public transport. It will provide parking spaces which will reduce the parking needs in the city center. The attractiveness and effectiveness of the park and ride rest on the location of parking, service quality, parking charges, and on-site facilities. As the number of vehicles increase, the need for parking facilities also increases. It is crucial to minimize traffic congestions, accidents, pollution and unwanted fuel use through parking management and policies.

Park and ride is a scheme where the provision of parking spaces at a site, with some distance and access to public transport to achieve the destination; a large offsite parking space with a shuttle-bus serving the workplace.

As highlighted the park and ride has two main purposes which are first, to shift the modal split towards public transport and second, to reduce the needs for parking spaces in town centre. Thus, trips to park and ride were considered as contributor to the increasing of car use. Later, it was argued that park and ride could induce a net increase rather than achieving reductions in traffic. It was highlighted that high frequency and low load were factors that park and ride buses caused in a net increase in the distance travelled in car equilibrium ierms.

Additionally, it was mentioned that the attractiveness and effectiveness of park and ride depend mainly on the locations and parking charges of facility, service quality and fares of public transits, road congestion, road tolls and parking charges at the city centre. The location of park and ride particularly in close proximity to residential areas, may serve users to use variety of modes (automobiles, motorcycles and pedestrian) as they transfer to transit or carpools.

It was discussed that the sites for park and ride should be designed to attract the motorist with pleasant surroundings and on-site facilities such as waiting areas. It was further explained that the sites must be integrated with other transport modes; with high quality buses operate at high frequency, generally between 8 and 15 minutes during peak periods and only one or two stops are usually made to minimize journey time.

Therefore, there exists opportunities for shared parking as some parking lots and on-street parking spaces were less full than others within a site. Further, high percentage of long term parkers indicates that there is demand to use the facility particularly among the work trip makers of the suburban population.

Lastly, parking is an essential part of the overall transportation and land development system. It also a means to help realize other community development objectives such as land use efficiency, good urban design and economic vitality. An oversupply of parking is costly for business, visually unattractive, and may negatively impact urban design and streetscape. Conversely, an undersupply of spaces may compromise access and circulation, and create spill over problems for adjacent uses. It is, therefore, important to ensure balance between oversupply and undersupply when planning for parking. Thus, parking utilization study is vital to produce a succinct analysis of existing parking dynamics that can be employed over time to support and inform decision-makers about the development of parking.[26]

In a private vehicle dominated society, where people are not willing to shift towards public transport, a multimodal transport system needs to be devised where there is a usage of both private vehicles and public transport. A park and ride scheme can fulfill this requirement to park cars and travel via public transport for the remaining journey. Similarly, for reducing long term congestion, solely relying on public transport will be ineffective rather park and ride schemes can be a solution to this. It has been observed that for encouraging parking at the park and ride station, the fare should be minimal or even preferably free. Socioeconomic related characteristics (and sociodemographic) have been viewed as one of the important determinants of urban travel patterns. It was highlighted that the extent of relationship between socioeconomic and travel behaviour patterns. It focused on both revealed preference as well as stated preference survey via stratified cluster sampling. The study revealed that the mean monthly household income of the non-park and ride users exceeded that of the park and ride users' mean income by about twenty percent (20%).

In terms of socioeconomic parameters, the study focused on gender, age as well as employment category. In terms of parking-related characteristics, it was stressed that if park and ride were to be encouraged, then the pricing of the station car parks should be low. They however cautioned that it would inevitably be affected by local competition and traffic management. It was pointed out that there is ample experience to suggest that parking at the interchange should be either very cheap or even preferably free so as to encourage park and ride usage.[27]

Likewise, it has been found that the reduction in car use can be achieved if limited parking spaces are available. As the number of vehicles increases, the need for parking facilities also increases. It is crucial to minimize traffic congestions, accidents, pollution and unwanted fuel use through effective parking management and policies. Park and ride is a scheme where the provision of parking spaces are allocated at a site, with some distance and access to public transport to reach users' desired destination; a large off-site parking space with a shuttle-bus serving the workplace. With efficient planning of service networks that attracts riders who may not have otherwise used transit, park and ride is considered as an ideal element of urban mass transportation systems.

Similarly it was highlighted that the park and ride scheme has two main purposes which are first, to shift the modal split towards public transport and second, to reduce the needs for parking spaces in town centres. Park and ride scheme will grant an access to the town centres with relatively little environmental damages from traffic.

Furthermore, the dissimilarities between on-street and off-street utilization rates in the urban sites tend to depend, in part, on the relative convenience of the on-street parking. Some other common problems identified at most of the lots were lack of security patrols, and some showed clear signs of vandalism, no sidewalk access, lack of bus shelters and signage on transit and ridesharing services were minimal.[28]

Parking demand is also affected by vehicle ownership, trip rate, parking duration, fuel price, and road pricing. Parking demand refers to the amount of parking that would be used at a particular time, place and price. It is a critical factor in evaluating parking problems and solutions. Parking demand is affected by vehicle ownership, among all other behavioural factors such as trip rates, mode split, parking duration and type of trip, and factors of other travel modes such as the quality of alternative travel, fuel and road pricing. [29] Usually, more parking means more autos and hence less transit. But that is the case when parking is provided at the destination.

Conversely, if the parking is near to the origin of commuting trips and the preferred mode to access BRT station is the automobile, an increase in the transit ridership can be expected. Many institutions provide subsidized or free parking as a complement to their services. The issues studied here extend beyond mass transit. If people are willing to change their behavior in response to parking availability in a transit context, it stands to reason that people will also change in their behavior in response to parking availability in other contexts.

However, in cases where parking can only be used by originating transit passengers it is complementary rather than competing.[30] These parking facilities will attract varying amounts of new traffic and will consequently change the traffic distribution and circulation patterns in the study area, depending on their locations and surplus capacities.[20].

Similarly, along with the park and ride for cars, Cycle Park and ride can attract passengers as well. Direct forecasting models involve adjusting a multiple regression model where the dependent variable is station ridership and the independent variables are the characteristics of the stations. A critical assumption for using direct forecasting models to assess the factors driving ridership at the station level is how to define the catchment area of a station. A station's catchment area is usually determined by the ''maximum'' walk distance or the area within which a majority of users arrive by foot. [31]

2.8 Regression Analysis

In the past ridership was estimated using cross-classification and trip rate analysis but nowadays, multiple regression models are widely used for estimating modal shift, ridership, and parking demands. They are time-saving, simple to use and easy to interpret. The regression analysis has an advantage over past methods that it addresses the particular station under observation while past methods were applied over large transport zones. Regression models better estimate the impacts of the station environment on travel demand. The four-step model was fed with costly mobility surveys while regression models require ridership data from a single station. The history of transport modeling has been dominated by the four-step model. The four-step model is a family of interrelated models (generation, distribution, assignment and mode choice) that are costly to implement and maintain. The initial purpose of the four-step model in the 1950s was traffic forecasting, mainly on a regional scale. Thus, it is not surprising that the four-step model is less effective for forecasting the journeys using public transport ion imore idetailed iscales. Direct imodels based on multiple regression analysis are a complementary approach to estimating ridership as a function of station environment and transit service features. Such models are a relatively rapid and less expensive alternative to the four-step model.

In addition, they better capture the influences of the station environment on travel demand. The elasticities reveal the repercussions of urban planning on ridership, such as new urban development and densification, which are particularly relevant in Transit-Oriented Developments (TOD). The combination of low cost and simplicity also makes them an appropriate tool for small towns, or those with limited financial resources, which require a quick and accurate assessment of the ridership forecast to plan investments in transport infrastructure. In this respect, it should be pointed out that the four-step model is fed by costly mobility surveys, whereas the direct forecasting model is fed by simple station ridership data. Thus, the strength of the relationship between the model variables will not be the same throughout the study area.

Traditional statistical models may show specification problems when the presence of spatial autocorrelation in the data is not considered. A major consequence of this is the risk of inefficient coefficients estimates to represent the magnitude of the relation between the variables, making statistical significance tests on them questionable. Thus, specific tests on the residuals are required before any regression analysis results are interpreted to statistically demonstrate their spatial randomness. When spatial autocorrelation is present, the use of a technique specifically designed for dealing with this type of problem. As a result, estimations can be fit to each observation or location by applying the appropriate equation.[32]

Regression analysis was also used to interpret the commuter's behavior in the selection of station to be approached for the trip and it was revealed that young commuters walk farther to access a rapid rail transit station. [18]

Travel time and travel cost were considered as the main variables to develop utility functions using binarly logit model. Based on these modal characteristics and the different service strategies offered, people perception and their probability of selecting the proposed system is predicted. The results show a wide range of people's perception and their probability of choosing the better service. The factors were identified that prevent personal transport users from utilizing public transport so that rational polices could be formulated to encourage greater utilization of public transport. Binary logit models were developed involving car and bus, car and train. The most important variables, found likely to encourage the use of public transport, were reduced travel time, walking distance to public transport stations and subsidized fare. At present, there is no research available in behavioral study of switching intention of personal vehicle users to buses under traffic conditions prevailing in developing countries. [3]

To conclude, parking is an essential part of the overall transportation and land development system. Since BRT can be an efficient solution to modern-day traffic complications but with the provision of proper parking spaces, the system can be upgraded at its utmost level. It will be an advantage to the developers for land-use efficiency, urban designing, and a robust economy. Balanced parking ensures boosted business activities, good aesthetics, and a proficient urban infrastructure.

CHAPTER 3

3 METHODOLOGY

3.1 Data Collection

The survey was conducted at 16 stations out of 31 stations. These stations were chosen based on their locations which cover a wider population catchment comprising mainly various types of residential areas expected to propel users to use BRT.[28] These stations are located in a suburban area and only the suburban area is provided with parking facilities at the BRT stations. These stations have a provision of adequate parking space, which cater to the parking demand and the parking area is not linked to other land use categories.[33]

The data was collected using the revealed preference approach (RP) and stated preference approach (SP). RP part questioned the current travel behavior and its perspectives while the SP part was regarding the future system and their expectations. Passengers were interviewed individually and the questionnaire form was filled. The survey comprised a total of 31 questions which enclosed three major information regarding the passenger: personal details or socioeconomic characteristics, travel characteristics and parking characteristics.

The individual's age, gender, education, income level, and vehicle ownership were enquired in personal details. In travel characteristics, the individual’s origin, destination, travel time, travel cost and whether they are ready to shift towards BRT were enquired. In parking characteristics, passenger’s opinion was taken regarding the parking location, facilities they are expecting, will they park their vehicles or not, an estimated amount of parking fare and the walking distance they are willing to cover from parking to BRT station.

The survey was conducted at both peaks (morning and evening) and off-peak hours. Similarly, data was collected on working days and weekends as well. A total of 498 passengers responded to the survey. Since the concern was the shift of the private vehicle owners (passenger cars (PC) and motorcyclists (MC)) to the BRT, therefore, only vehicle owners were selected and the remaining responses were obliterated. Out of the total respondents, 433 were vehicle owners.

Mostly, travellers were reluctant to provide information and the whole procedure was handled quite carefully. The surveyors were deployed at concerned stations at various times of day and days in a week. Students were mostly willing to fill the forms whereas people who had jobs were not ready to provide information. The people from all walks of life and from all age groups were interviewed. Travellers aged 20-40 comprised of about 66% of the whole data. 21% were from 40-50 and 9% from 50 to 60. Above 60 and below 20 both were 2%.

Regarding the gender, males were rather easier to survey as compared to females. Females were mostly students and a little bit were out for shopping. Working group in females was quite less. Younger people were willing to travel to stations more than older ones and people of lower middle class were willing to walk more than upper classes.

3.2 Sample Details

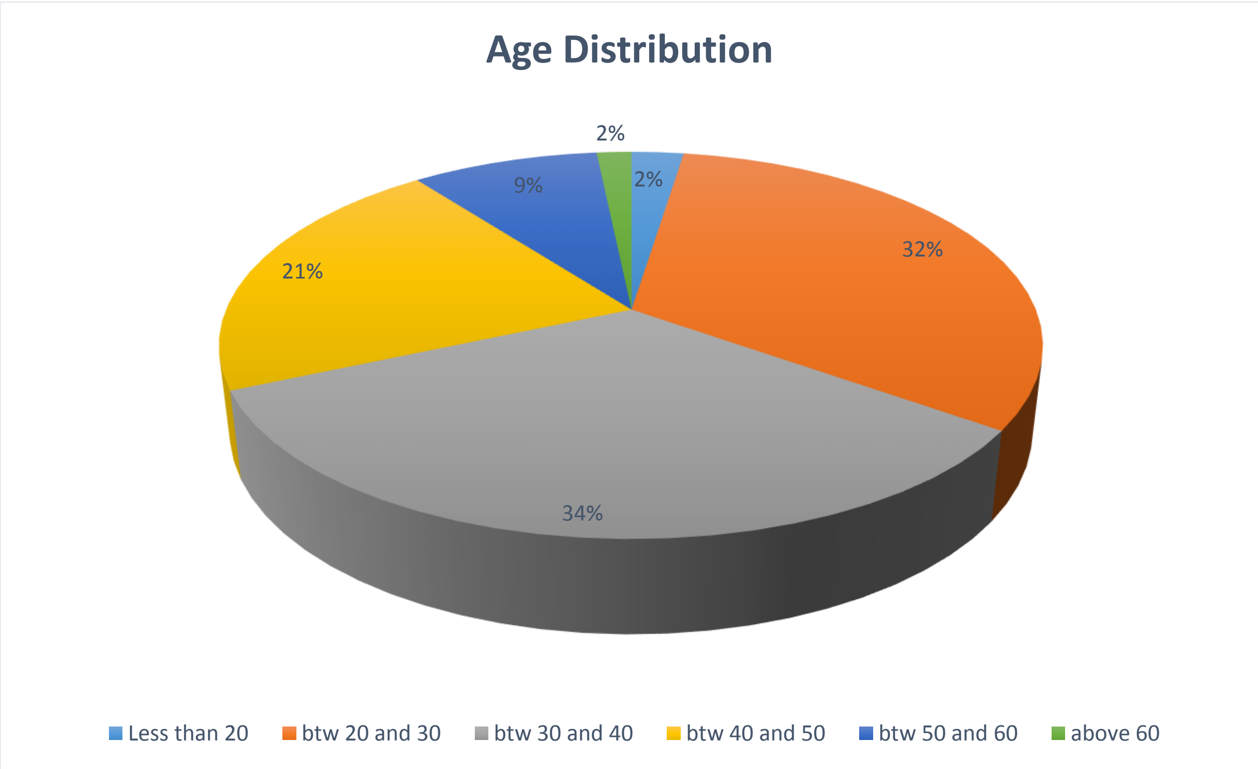

Figure 1: Age Distribution

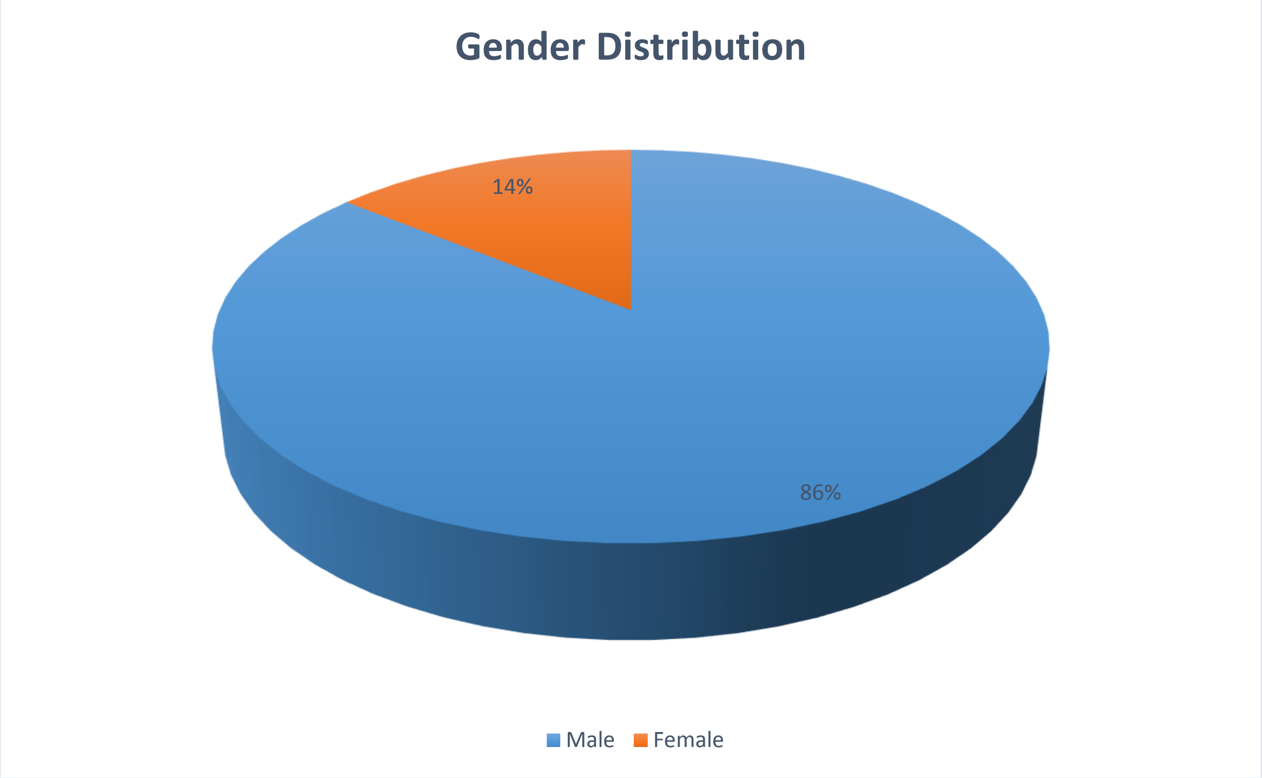

Figure 2: Gender Distribution

Each commuter was asked about his trip purpose and his behavior towards BRT for the same trips. Similarly, their willingness for out of vehicle travel time was also interrogated. Following pie charts illustrate it:

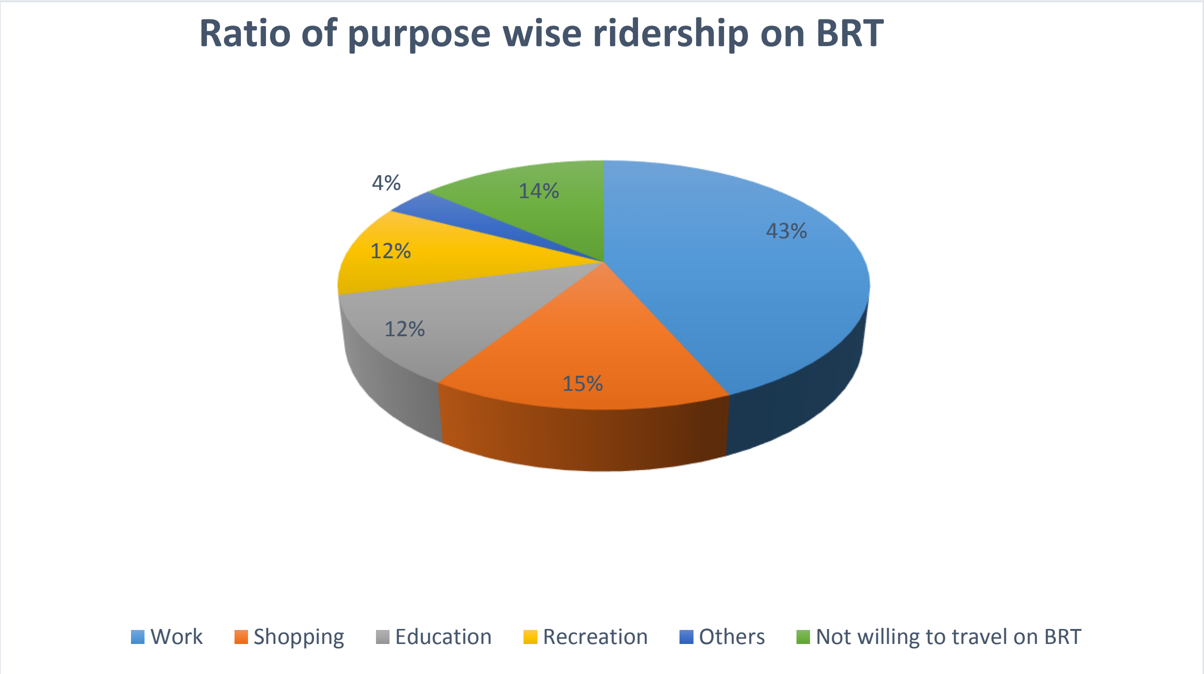

Figure 3: Ridership on BRT on the basis of purpose

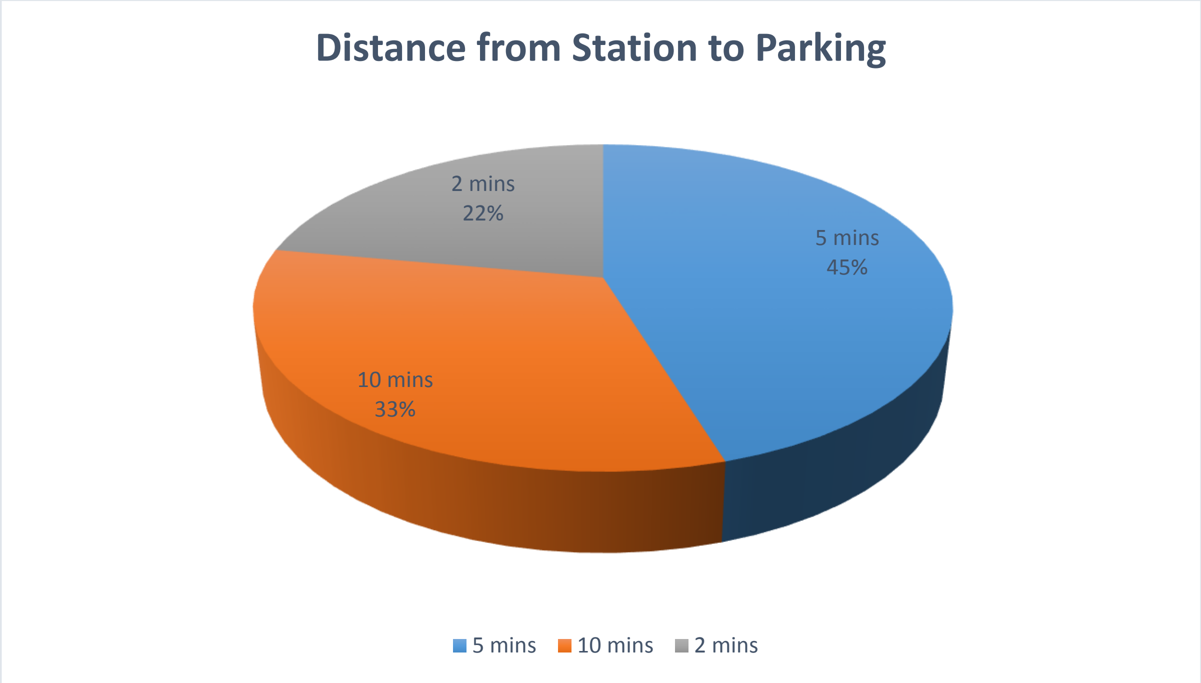

Figure 4: Willingness of OVTT

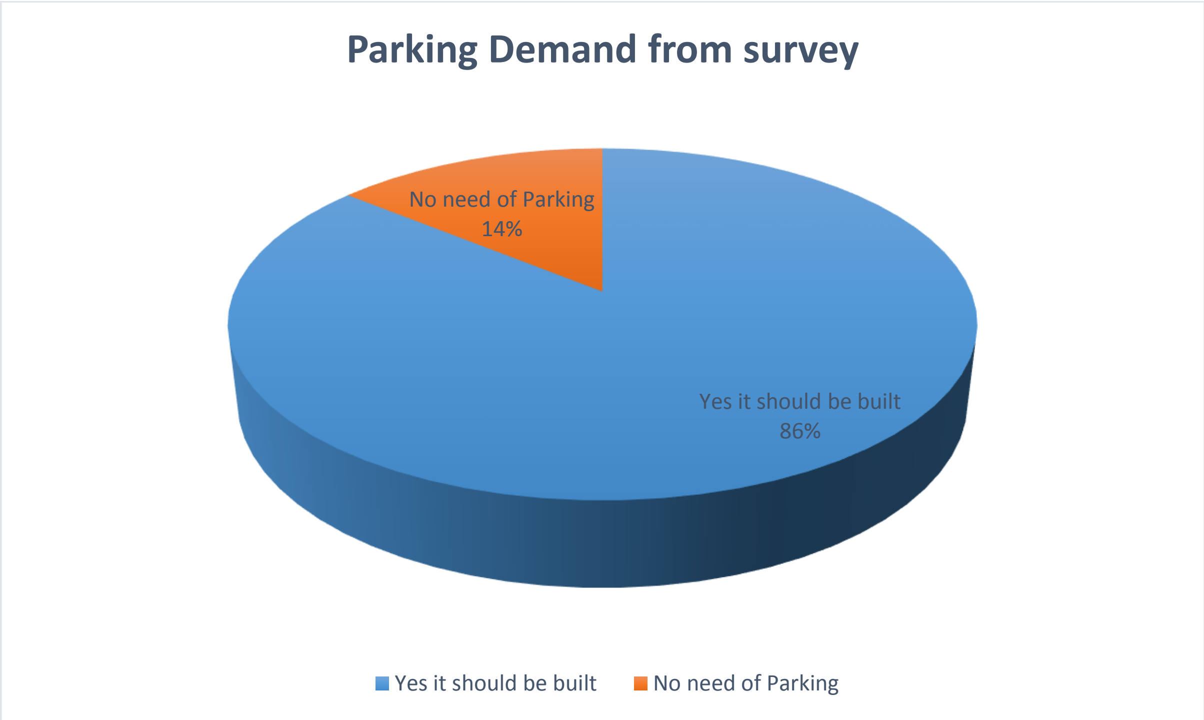

Figure 5: Parking Demand of commuters willing to park vehicles

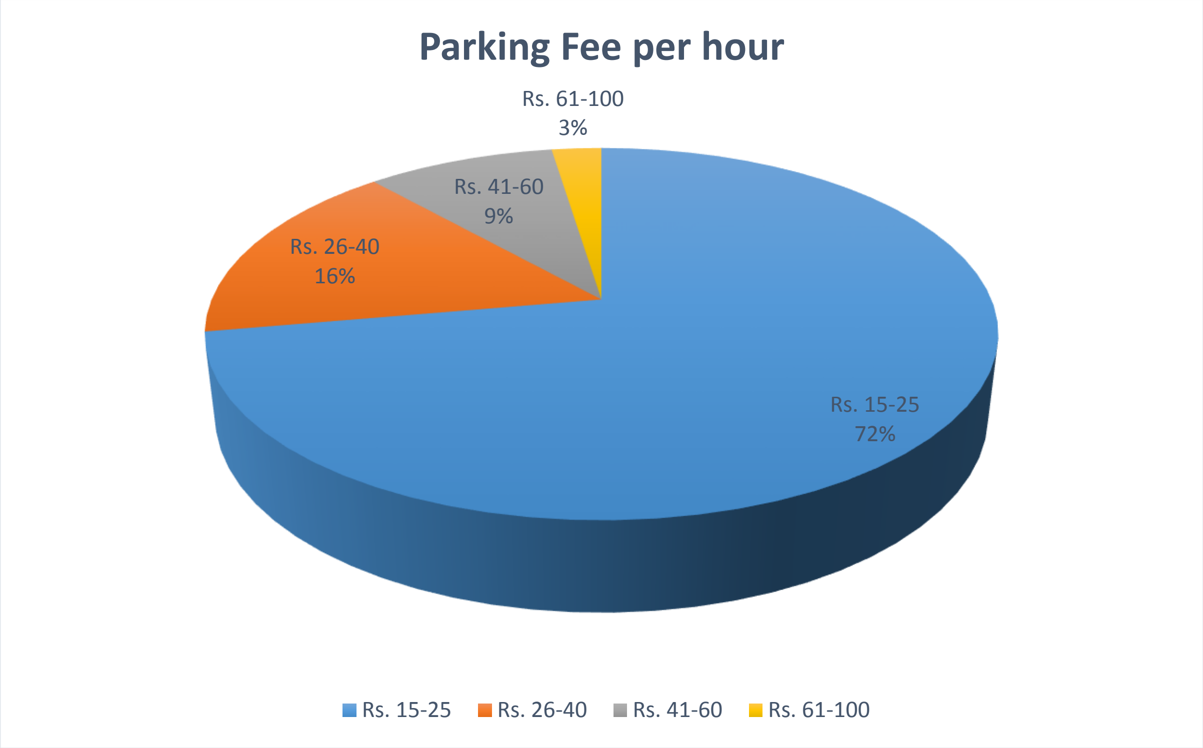

Figure 6: Parking Charges obtaine from survey

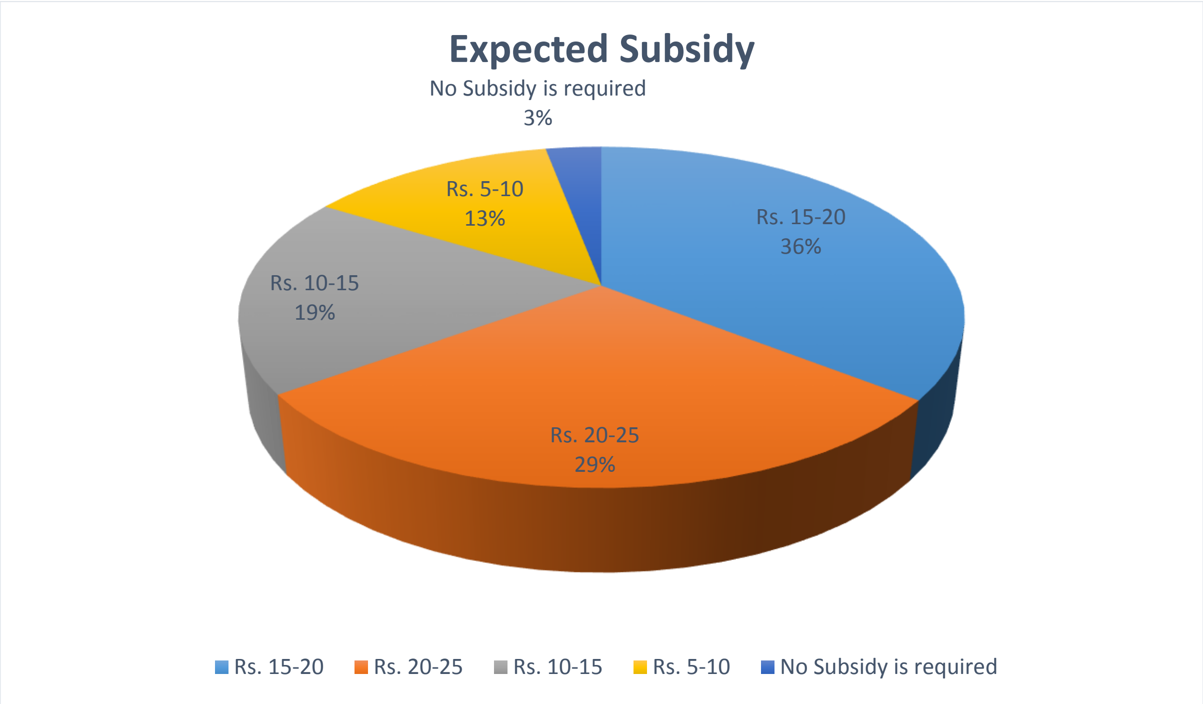

Figure 7: Subsidies people are expecting for parking the vehicles

The average education level of respondents was grade 13. The average income of car owners per month was PKR. 37253 whereas for motorcyclists it was a bit lower i.e. PKR. 28967.

3.3 Model Development

3.3.1 Modal Shift Analysis

The model is based on utility theory which assumes that commuters opt for the mode which maximizes their utility. The multinomial logit model has been used in this study for estimating the modal shift from private vehicles to BRT. The equation for the model can be given as:

$$\mathrm{P}_{BRT} = \frac{e^{\Delta U}}{(1+e^{\Delta U})}$$

Converting this equation into:

$$\Delta \mathrm{U} = \ln(\frac{1-P_{BRT}}{P_{BRT}})$$

Where,

ΔU = change in the utility from the existing system towards BRT.

P_{BRT} = probability of BRT (percent of the people opting for BRT)

Using the above equation, utility at each station was estimated whereas P_{BRT} was obtained from the survey. For estimating the modal shift, change in travel time and travel cost of trips at each station were used. Travel time of BRT was estimated using the speed at which the buses will run i.e. 40km/hr. Similarly, travel cost was calculated using the fares given by the consultants Mott Mac Donald Pakistan (MMP). Travel costs varied according to the distance. For travelling less than 10 km it would be Rs. 25. From 10 to 15 km it would be Rs. 35. Similarly, above 15 km it would be Rs. 50. Travel time and travel costs of the current system were obtained from the SP survey.

Change in travel time was used i.e.

Δ Time= (Travel Time current system) – (Travel Time BRT). Similarly, change in cost was used i.e.

Δ Cost= (Travel Cost current system) – (Travel Cost BRT). Along with these two variables, three more variables age, education, and income level of individuals at the relevant stations were used to estimate the modal shift. These were taken as average as per survey findings.

Now regression analysis was performed in excel by setting ΔU as dependent variable and ΔT, ΔC, age, education, and income level as independent variables. ΔU

Obtaining the values of regression coefficients from regression analysis and putting in:

$\Delta U = \beta_o + \beta_1 (\Delta T) + \beta_2 (\Delta C) + \beta_3 (\text{age}) + \beta_4 (\text{education}) + \beta_5 (\text{income level})$

Now obtaining ΔU from the above equation and putting in:

$$P_{BRT} = \frac{e^{\Delta U}}{(1+e^{\Delta U})}$$

The probable shift from personal vehicles (PC and MC) to BRT was obtained.

3.3.2 Parking Analysis

Now the utilities for a shift with the availability of parking spaces at concerned stations were estimated. For this analysis, those commuters who were vehicle owners and not willing to travel via BRT were also excluded. It comprised 43 respondents and the remaining 390 were used for parking analysis. Similarly, parking time and parking fare were also added in the BRT travel time and fare respectively in this analysis. Parking fare was taken as average from parking fares (willing to pay) responded by respondents in the survey. Another variable OVTT was also introduced in this analysis i.e. the distance people were willing to walk from parking to BRT station. Obtaining utilities from the following equation:

$$\Delta U_{parking} = \ln\left(\frac{1 - P_{\text{BRT(parking)}}}{P_{\text{BRT(parking)}}}\right)$$

The utilities obtained from the above equation for the respective stations were put as dependent variable and ΔT, ΔC, age, education, income level, and walking distance as independent variables in excel for regression analysis. Obtaining the values of regression coefficients from regression analysis and putting in:

$\Delta U = \beta_o + \beta_1 (\Delta T) + \beta_2 (\Delta C) + \beta_3 (\text{age}) + \beta_4 (\text{education}) + \beta_5 (\text{income level}) + \beta_6 (\text{walking distance})$

Now obtaining ΔU from the above equation and putting in:

$$P_{BRT(parking)} = \frac{e^{\Delta U(\text{parking})}}{(1 + e^{\Delta U(\text{parking})})}$$

The average of commuters who were willing to park their vehicles was obtained out of the commuters who were willing to shift from private vehicles to BRT. Since the above-made analysis was for both cars and motorcycles. Motorcycles users (MC) were analyzed separately to obtain an exact parking estimate for motorcycles.

3.3.3 Parking Analysis of Motorcycles

In this analysis, those commuters were assessed who were motorcycle owners and willing to shift their mode of travel. The procedure was the same with just the exclusion of car users. It changed the variables accordingly and change in utilities for the parking of motorcycles was calculated using:

$$\Delta U_{bikes\ parking} = \ln\left(\frac{1 - P_{\text{BRT(bikes parking)}}}{P_{\text{BRT(bikes parking)}}}\right)$$

Regression analysis was performed with ΔU as the dependent variable and ΔT, ΔC, age, education, income level, and walking distance as independent variables. Obtaining the values of regression coefficients from regression analysis and putting in:

$\Delta U = \beta_o + \beta_1 (\Delta T) + \beta_2 (\Delta C) + \beta_3 (\text{age}) + \beta_4 (\text{education}) + \beta_5 (\text{income level}) + \beta_6 (\text{walking distance})$

Now obtaining ΔU from the above equation and putting in:

$$P_{BRT(bikes\ parking)} = \frac{e^{\Delta U(\text{bikes parking})}}{(1 + e^{\Delta U(\text{bikes parking})})}$$

From this, we determined the percentage of motorcyclists willing to park their motorcycles.

3.4 Model Validation

The validation was done by comparing the results with the study made by MMP. Since they have designed three park and ride stations on the BRT with two at both ends and one in the middle of the route adjoining the city hub i.e. Dabgari Garden. The same station was selected for the validation purpose in this study where 128 parking spaces were obtained for cars while they (consultant) obtained 126 parking lots.

The R-square values for modal shift analysis, parking analysis of private vehicles (cars and motorcycles) and parking analysis of motorcycles are .82, .83, and .82 respectively. R-square values for a transportation model analysis is acceptable above .8.[34] Another study suggests that the R-square value of .70 is acceptable in the transportation model with five to six variables.[35]

Another test is the p-value and t-stat which shows the dependence of the dependent variable on independent variables. An absolute value of 1.96 or greater of t-stat and 0.05 or less of p-value implies that all presented co-efficient in the model are significant at a 95% confidence level. In the first two models, all variables are fulfilling the criteria except ΔT. Similarly, in the last model ΔC was not fulfilling the criteria. The previous studies in this regard suggest that a single variable not satisfying the criteria is acceptable and it doesn't affect the model's confidence level.[36]

CHAPTER 4

4 RESULTS AND DISCUSSION

4.1 Results of Model Development

The model for estimating modal shift and parking demand was formulated in MS Excel. With setting ΔU as dependent variable and ΔT, ΔC, age, education, and income level as independent variables and performing regression analysis resulted in the formulation of following equations:

Table 1: Equations Developed from Models

Users	Multinomial Logit Models	R-square
Modal Shift (PC and MC)	ΔU_{BRT}= 1.66 + 0.008(ΔT) + 0.015 (ΔC) - 0.055 (age) – 0.116 (education) + 1.022E-05 (income level)	0.82
Parking (PC and MC)	$\Delta U_{parking}$ = 3.465 + 0.013(ΔT) +0.0045(ΔC) – 0.078(age) – 0.172 (education) + 1.06E-05(income level) - 0.048 (walking distance)	0.83
Parking (MC)	$\Delta U_{bike\ parking}$ = 0.65 + 0.033(ΔT)+0.006(ΔC) – 0.027(age) –0 .036 (education) – 1.28E-05(income level) - 0.037 (walking distance)	0.82

Now by putting the values of variables obtained from the survey were put in these equations to obtain the results. A 13 percent shift was observed from private vehicles to BRT. It reveals that a major portion is still not willing to come out of their private vehicles. From these 13 percent commuters, 14 percent are willing to park their vehicles at BRT parking lots with a parking fare of PKR. 20. This parking percentage can be improved by providing subsidy on parking the vehicle. Subsidy can be in terms of remitting the parking charges which menas free parkings. Under such circumstances, the parking paercentage can be increased 1 percent i.e. 15 percent. Out of this 15 percent, 76 percent are car users and remaining are motorcycles users. It concluded that 24% out of 15% of parking users were motorcyclists.

Most of the commuters which were not willing to park their vehicles were because of inconvenience, safety and security reasons. Hence, addressing these issues may increase parking percentage.

The results from the above equations are as follows:

Table 2: Results from Developed Models

Stations	P_{BRT}	$P_{BRT\ Parking}$	$P_{BRT\ motorcycle\ parking}$
Haji camp	0.13	0.16	0.25
Gulbahar	0.14	0.16	0.23
Firdous	0.13	0.15	0.21
Shuba Bazar	0.12	0.13	0.23
Dabgari Garden	0.12	0.14	0.25
Saddar	0.13	0.16	0.23
Aman Chowk	0.12	0.15	0.24
Tehkal	0.14	0.17	0.25
Abdara Road	0.12	0.15	0.24
Town	0.13	0.16	0.22
Peshawar University	0.13	0.14	0.25
Board	0.13	0.14	0.25
Phase 3	0.14	0.16	0.26
Tatara Park	0.13	0.15	0.24
PDA Hayatabad	0.12	0.15	0.23
Karkhano	0.12	0.14	0.20

4.2 Parking Estimation

For computing the parking spaces that are required to be built at the corresponding station, the ridership data was obtained from the report prepared by the consultants for design purposes. The product of ridership and percentage of people who (will shift from private vehicles to BRT and) will park their vehicles as well, was calculated to obtain overall parking demand. Now, the parking demand for cars was obtained by multiplying overall parking demand (15%) with cars percentage i.e. 76% while the remaining 24% were motorcycles parking. To cope with land availability issues, multi-storied parking can be considered a solution. It was observed that five motorcycles can be parked at one parking space of passenger car, therefore, for construction purposes, 24% is divided by 5 and then added with parking spaces for passenger cars. The calculations are presented in the following table:

Table 3: Parking Estimation

Stations	**P BRT parking**	Demand as per model for PC and MC	Demand as per model for PC	Demand as per model for MC	Parking Spaces required to be built
Haji camp	0.16	454	342	112	364
Gulbahar	0.16	268	207	61	219
Firdous	0.15	215	171	44	180
Shuba Bazar	0.13	83	64	19	68
Dabgari Garden	0.14	170	128	42	136
Saddar	0.16	291	224	67	237
Aman Chowk	0.15	231	177	54	188
Tehkal	0.17	195	147	48	157
Abdara Road	0.15	173	131	42	139
Town	0.16	262	204	58	216
Peshawar University	0.14	331	248	83	265
Board	0.14	291	217	74	232
Phase 3	0.16	186	138	48	148
Tatara Park	0.15	75	57	18	61
PDA Hayatabad	0.15	58	45	13	48
Karkhano	0.14	236	189	47	198

4.3 Discussion

1. It is evident from the model that for the modal shift, the co-efficient of change in travel time and travel costs are positive. The preference of travelers will increase with decreasing travel time. Similarly, with decreasing BRT fare, the preference is increasing which shows passengers are expecting a rapid and good quality service with a reasonable ticket price.
2. Regarding the parking analysis of cars and motorcycles, the preference for parking increases with reducing parking time. The co-efficient of change in the cost of overall parking is positive indicating that decreasing parking fare increases the preference. Likewise, the preference increases for motorcycles by decreasing the cost of parking. The subsidy for parking the vehicles was considered in the analysis and it was observed that with the subsidy, only 1 percent increase in the ridership can be achieved.
3. The sign of co-efficient of age for modal shift and parking analysis both is negative which means with increasing age, the BRT and parking preferences are decreasing. Since younger commuters have no private vehicles so they want to shift towards an efficient public transport system rather than that out of date system. While older passengers mostly prefer their private vehicles to get rid of waiting, access and egress times in public transport systems.
4. The sign of co-efficient of education indicates that an educated person is less likely to prefer BRT and parking because of status issues.
5. The sign of co-efficient of income level for modal shift indicates that with increasing income level, the preference of BRT is increasing. Mostly, lower-class people are motorcycle owners and prefer it instead of BRT to save their time. On the other hand, the middle class prefers BRT until their income level is less than PKR.80000 per month. It is because of the affordability issues since running private vehicles is expensive as compared to BRT. Achieving a certain income level, they feel easier and comfortable with private vehicles as it is affordable for them.

   As far as the parking is concerned, with an increasing economic level overall parking preference increases because they can afford and want to park their vehicles somewhere. While it decreases for motorcycles parking as they usually don't prefer parking to avoid the parking fee. Given the BRT fare and parking charges, the motorcyclists are reluctant to park their vehicles.

6. The preference for overall parking and motorcycles parking decreases with an increasing walking distance. People usually don't prefer to walk to stations for more than 7 to 8 minutes.

CHAPTER 5

5 APPLICATIONS AND CONCLUSIONS

5.1 Applications of Developed Models

The developed models can be used to determine the modal shift for different scenarios regarding travel time and travel cost of BRT. The shift can be transformed by reducing the travel time of BRT by reducing egress and access time, increasing the frequency of buses and bus priority measures. Up-gradation and facilitation of BRT at par with the private vehicles will attract more middle class. The provision of subsidy can attract lower class commuters as that more feasible and economical to them. The provision of different parking facilities for different age groups and gender may magnetize more people to BRT. Further, special provisions for disabled and older commuters to reduce their waiting times can attract more users. Moreover, decreasing the utility of private vehicles by increasing travel costs, direct road pricing, the increased fare for parking at authorized parking spaces and heavy fines at un-authorized spaces can increase the shift. Similarly, increasing the purchasing cost of vehicles, tax on entering the city and congestion tax, reducing speed limits may also enhance modal shift. Also, the provision of parking lots near to stations for reducing out of vehicle travel time and feeder service for reducing door to door travel time can be an efficient method to increase modal shift. Parking promotional initiatives e.g. free Sunday parking, subsidy on BRT parking and awareness programs may boost the shift. Besides these, information technology and employment of different applications to provide real-time information about parking availability and automatic ticketing system for decreasing time wastage may bring dramatic changes in the modal shift from private to BRT vehicles. Finally, the provision of extra facilities e.g. canteen, rest area, mechanic shop, security, proper staff, and special places for women may enhance the modal shift.

5.2 Conclusions

This paper examined the potential of the shift from private vehicles to BRT and the potential of parking for commuters. Stated Preference Approach was used to survey passenger car and motorcycle users. The Multinomial Logit Model was used to find the probable shift from private vehicles to BRT and the parking spaces required at selected stations. The results obtained were compared with the results of MMP for validation. Travel time and cost were the two variables that displayed the interest of the middle class and the unwillingness of the lower and upper class for BRT. The travel time can be reduced by improving egress, access services, increasing service frequency and advanced parking system with an automatic ticketing system. Moreover, the modal shift can be transformed into BRT by taking initiatives such as increasing car purchasing cost, direct road pricing, and ushering facilities for aged and disabled people. Similarly, multi-storeyed parking can be considered to cope with the shortage of land space. These provisions would alleviate the congestion issues in the city by reducing car volume on the roads. To conclude, the BRT system should provide a decrease in travel time, the reasonable fare for low and medium-income people, well-designed park and ride stations, feeder services and effective policies to restraint vehicle usage with proper awareness programs.

5.3 Recommendations

This study can be expanded more by considering more independent variables for analysis like vehicle ownership, type of vehicle owned, gender, population density, land use, household size, driving license and comfort index. The study can further be used for studies in the planning of city. Similarly, studies regarding the traffic management can be conducted by considering these findings. It can be found whether from this percentage of shift, the prevailing conditions of traffic will change or remain same. Whether the current congestion will be alleviated? This needs another complete study to be conducted for future planning.

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Appendix 1

Questionnaire Survey Form

Personal Details:

Name: ____________________________ Age: ____________________

Gender: ___________________ Education: ___________________

Occupation/ Job: ________________ Family Size: __________________

School going kids: ________________ Means of Travel: __________________

1. Do you own a car/ motorcycle/ cycle? (If yes)
   How many?

   Cars (1, 2, 3) Bike (1, 2, 3) Cycle (1, 2, 3)

Travel Characteristics:

2. What is your preferred mode of transport:

>for work	> for shopping	>for recreation
• Public Transport	Public Transport	Public Transport
• Taxi / Rickshaw	Taxi / Rickshaw	Taxi / Rickshaw
• Self- owned vehicle	Self- owned vehicle	Self- owned vehicle

3. For your yesterday's trips:

No.	Start Time	Purpose	Duration	Origin	Destination	Mode	Cost
1.							
2.							
3.							
4.							
5.							

Parking characteristics:

4. Would you prefer BRT for going to:

   Work   Shopping   Education   Others

5. Do you want the parking lots to be built along BRT route? (Yes / No)

6. Are you willing to park your vehicle in these parking lots?

   ______________________ (If not)

   Security   Safety   Inconvenience   Others

7. Are you willing to park your vehicle in these parking lots on a subsidized fare?

   Rs. 50-100   Rs. 100-200   Rs. 200-500 (per day)

8. How much can you pay for parking per hour? (In Rs.)

   Rs.15-25   Rs. 26-40   Rs. 41-60   Rs. 61-100

9. Would you like to park your vehicle with your parking fee included in BRT monthly fare? (Yes / No)

10. Would you like to park your vehicle on a subsidy in BRT fares? (Per ride)(Yes / No)

    Rs. 5-10   Rs. 10-15   Rs. 15-20   Rs. 20-25

11. How much maximum distance can you cover by foot from parking to BRT station?

    2 minutes   5 minutes   10 minutes

12. Would you like to suggest a parking lot to be provided at any specific station at BRT?

    ____

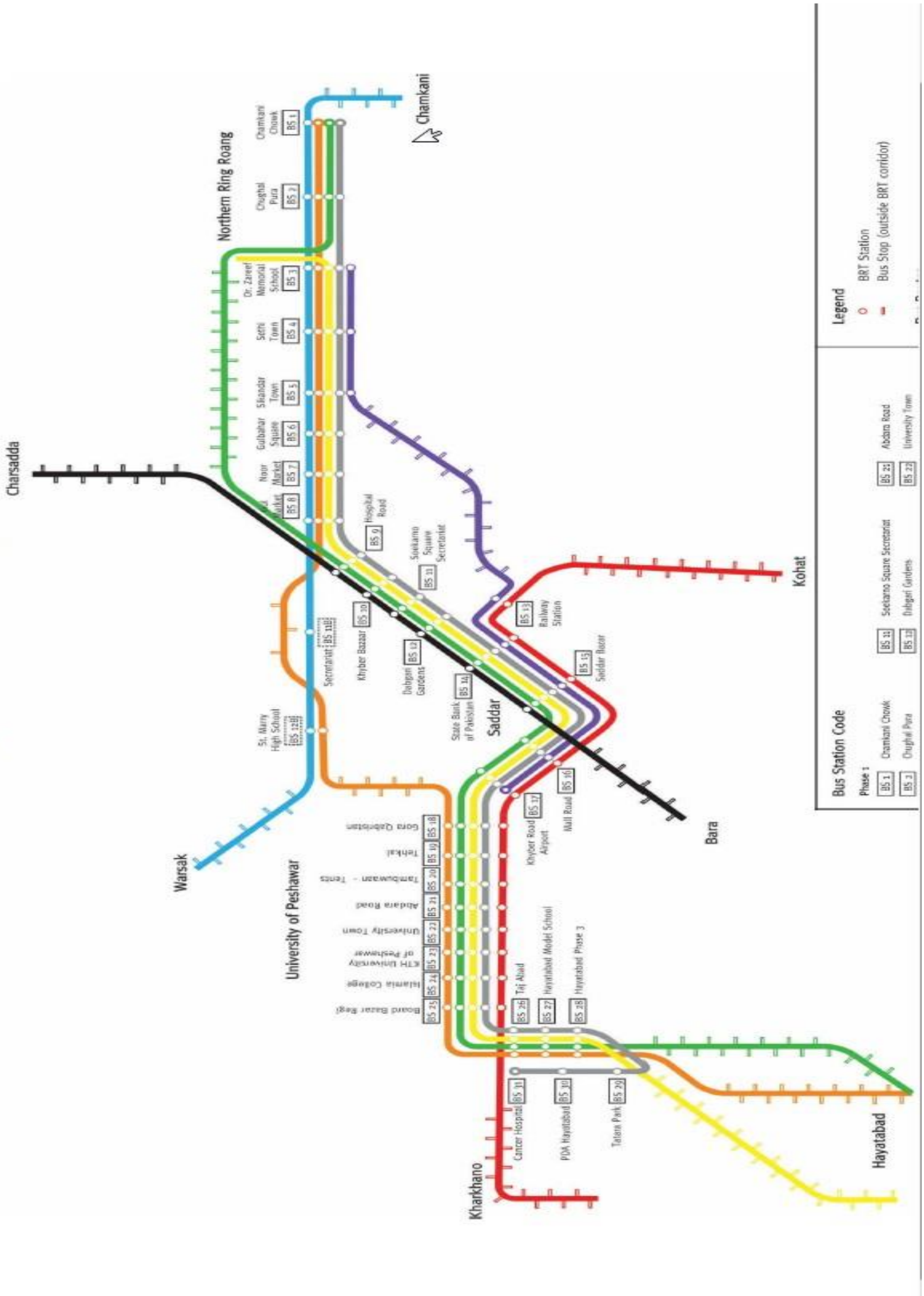
13. What other facilities you want at parking?

    ____

    ____

    ____

BRT Route Map



Bus Station Code

Bus Station Code

Phase 1

BS 1	Chamkani Chowk	BS 11	Soekarno Square Secretariat	BS 21	Abdara Road
BS 2	Chughal Pura	BS 12	Dabgari Gardens	BS 22	University Town
BS 3	Dr. Zareef Memorial School	BS 13	Railway Station	BS 23	KTH University of Peshawar
BS 4	Sethi Town	BS 14	State Bank of Pakistan	BS 24	Islamia College
BS 5	Sikandar Town	BS 15	Saddar Bazar	BS 25	Board Bazar Regi
BS 6	Gulbahar Square	BS 16	Mall Road	BS 26	Taj Abad
BS 7	Noor Market	BS 17	Khyber Road Airport	BS 27	Hayatabad Model School
BS 8	Gul Market	BS 18	Gora Qabristan - Christian Cemetery	BS 28	Hayatabad Phase 3
BS 9	Hospital Road	BS 19	Tehkal	BS 29	Tatara Park
BS 10	Khyber Bazaar	BS 20	Tambuwaan - Tents	BS 30	PDA Hayatabad
				BS 31	Cancer Hospital

Phase 2

BS 11B	Secretariat
BS 12B	St. Mary High School

Appendix 2

Questions asked in the defense

1. How have you validated your findings?

   Refer to page 45 and 46.

2. How have you estimated parking spaces?

   Refer to page 48 and 49.

3. What is the relationship of a single variable with modal shift and parking willingness?

   Refer to page 49 and 50.

4. How have you identified the parking zones?

   Refer to page 37.

5. What was the travel time and travel cost of BRT considered?

   Refer to page 42.