



Identification of Factors Affecting Modal Shift in Lahore

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Abstract: The popularity of Metro Bus System (MBS) on the whole is increasing in different cities of developing countries that are looking for cost effective sustainable mass transit solutions. One such example is Lahore, which is under grave influence of poor urban public transportation system. To improve this, MBS was introduced on one of its busiest corridors from Shahdara to Gajjumatta in 2013. The idea proved to be a great success since it started achieving its objectives i.e. to shift the commuters from their self owned vehicles or para-transit system to a mass transit system. It is very efficient, comfortable and cost effective public transport service. This study aimed at studying the key indicators that influence possible modal shift that can be achieved as a result of extension of MBS from Shahdara to Kala Shah Kaku (KSK). For the rationale to fulfill this research, a road user perception interview survey was conducted in the study area. A Model is developed using binary logistic regression for MBS and Qingqi. The possible modal shift from Qingqi is also studied. It is estimated that 89% of the commuters are willing to shift from Qingqi to the proposed MBS. These potential commuters primarily belonged to lower-middle income group and their mode choice is predominantly influenced by travel time, travel distance and cost. Travel time was found to be the most significant variable. It is suggested that providing mass transit system with low fares and minimum headway may be a great success on this corridor.

Keywords: Metro bus system, binary logistic regression, qingqi, public transport, modal shift, public transport

1. INTRODUCTION

In developing as well as in developed countries of the world improvement of public transport system has become a key concern in transportation planning. In Pakistan, existing condition of Public Transport (PT) is poor mainly in metropolitan city of Lahore and Karachi.

Lahore is Punjab's provincial capital and the second largest urban centre of Pakistan where 22 percent urban population of Punjab resides [1]. According to the Punjab Development Statistics [2], total number of vehicles registered in Lahore to date is 3.992million in recent past, a rapid growth in population and vehicle ownership in city has been observed which has resulted into traffic congestion. Only 16% of city's total trips are made on public transport which is the lowest percentage among all south Asian cities [3].

The introduction of sustainable mass transit system is one of the solutions that reduce traffic congestion and accidents rate. MBS in PT planning is favoured in many Asian developing cities because of its lower investment cost and flexible implementation over rail system [4]. A great deal of research has gone into investigating planning, performance, and operation of Bus Rapid Transit (BRT); however, relatively less has been done to assess whether its introduction has actually had an appreciable effect on transit use [5].

In order to cope with the ever increasing traffic congestion in Lahore city, MBS has been introduced in 2013. According to a few academics and professionals a very formal definition for BRTS is: "Bus transit designed as an integrated system of distinct buses and a separate infrastructure with considerable independence from other traffic,

allowing higher speed, reliability and safety than the Bus Transit System (BTS)” [6]. It has dedicated corridor from Northern suburb of Lahore i.e. Shahdara to south-east direction Gajjumatta. According to Punjab Mass Transit Authority, Shahdara station has highest daily ridership of 25,672. The introduction of MBS has reduced travel time and travel cost for passengers. A large amount of people make trips from nearby cities/villages like Rana Town, Sheikhpura, Muridke, Imamia Colony, Kamoki, etc. for work and educational purposes.

As Lahore city is expanding on the Grand Trunk (G.T.) road towards Gujranwala and various residential societies like S.A. Garden etc are now developing on north bound of Shahdara Station towards Muridke. It is now been proposed to extend MBS Lahore to this side of the city, i.e., Shahdara to KSK (study area). This research is initiated with a scope to identify the key parameters that influence commuter’s modal shift from Qingqi to MBS.

2. MATERIALS AND METHODS

An understanding of the attitude and behaviour of commuters is a necessary condition in the creation of an effective transportation system intended to encourage more efficient urban public transportation [7].

For primary data collection, a road user perception survey was conducted at Shahdara Mor and KSK Toll Plaza. The population of the study area was calculated by adding population of all Union Councils that lie in a range of 500 m from the G.T. Road on both sides after extrapolating census population of 1998. A sample of 288 commuters were interviewed using W.G. Cochran method for 95% confidence interval of the estimated population [8]. Each commuter was given seven choice sets where he/she had to select the different current modes of travel along with the option of proposed extended Metro Bus System. The approach of survey conducted in the field is based on Stated Preference (SP) and this lead to the development of model for the proposed extension of Lahore MBS. The survey was scheduled in order to cover the morning, noon and evening peaks.

Binary logistic regression analysis was employed using various attributes and commuter’s preference to estimate the relative importance of the proposed MBS attributes. The methodology utilized is outlined in detail in Ben-Avika and Lerman [9]. Logit models determine the significance of mode choice based on attributes on each individual. This can be expressed as:

$$P_q(\text{Qingqi to BRTS Mode}) = \frac{e^{U_{\text{Qingqi}}}}{\sum (e^{U_{\text{Qingqi}}} + e^{U_{\text{BRTS}}})}$$

In order to study travel characteristics of the commuters, questions were asked like total travel time, preferable mode of transport, alternative available modes of transport, cost of the total trip, the total distance travelled etc. For detailed study and analysis, secondary data was also collected from sources included Lahore Urban Transport Master Plan Study by JICA [10].

2.1 Study Area

The study area for this research is adjacent area to proposed corridor for the extension of Lahore MBS from Shahdara to KSK as shown in Fig. 1.

The marked centreline shows proposed extended route’s starting point from Shahdara Mor and ending at KSK. It has typical mixed land use pattern that passes near many industrial and educational Institutions along with KSK Interchange which connects this corridor (G.T. Road) with Motorway M-2. The length is 9 km for proposed corridor.

2.2 Existing Condition of Public Transport

The situation of Public Transport system of Shahdara towards KSK on G.T. road is poor. Lahore Transport Company (LTC) is operating two bus routes B-49 and B-49-A. Ridership of these bus routes was calculated using boarding and alighting survey, starting from Shahdara Mor to KSK Toll Plaza in both directions. The calculated daily ridership was about 4,373 in both directions of this area. The estimated commuter ridership of PT in this stretch was 15,397. Only 31% PT users have waiting time less than 5 minutes at bus stops. Due to higher waiting time, the most popular mode of PT is Qingqi/Motorcycle Rickshaw. The

usage of this mode is about 49%. As a result less passengers use LTC buses and other PT modes despite of high potential of PT users in this area. The existing mode of travel of study area is shown in Fig. 2.

2.3 Data Collection

This research covers socio-economic factors that can affect trip characteristics and mode choice decision. Therefore, household type, trip patterns and their characteristics and personal demographics were selected. A deep rooted and intense relationship exists between the socio-economic characteristics and the travel demand of the commuters. For example, study of Surat City, India identified that Income, Gender, Trip Length, Trip Frequency, Travel Time and Travel cost are major factors that cause variation in modal shift behavior of various modes to MBS [11]. In order to determine the potential of modal shift, traffic counts alongwith PT vehicle boarding and alighting survey were conducted at Shahdara Mor and KSK Interchange for through traffic from Shahdara towards KSK. Further, LTC buses vehicle occupancy survey was done and MBS user perception survey at Shahdara Station of MBS Lahore was conducted. Also PT and private vehicle users were asked about their willingness to shift to MBS if it is extended to KSK.

2.4 Statistical Technique

Binary logistic regression analysis technique is used to develop models in order to study which attributes were significant in predicting the choice of transportation mode. As the willingness to shift to MBS is dichotomous, this approach helps to study about the relationship of independent variables on dependent variables.

The utility equation was developed after the data analysis in SPSS. These equations are developed for various modes including the MBS. Calculated willingness of the commuters to shift from local public transport modes available to the extended proposed MBS corridor was computed for assessing the possible modal shift if the project of proposed MBS extension is executed. Another analysis is done in SPSS to study the impact of trip behaviour / characteristics and different individual

on the utility value of a particular mode including the MBS. This study was done using the binary regression model prediction about the change in the public transportation system with reference to the modal sharing are further analyzed by the options selected for choice set by each respondent.

3. RESULTS AND DISCUSSION

Based on the user interview survey in the study area, the results showed that the majority of commuters were male of age between 14 to 30 years. It is important to note that in Pakistan, mostly male members of the household support their families especially in lower and middle income class group of the society.

Children below 14 years make trips on the decision of their parents and it is also difficult to interview them. Therefore they were not considered in the survey. Average Annual Daily Traffic (AADT) was calculated from Traffic counts surveys. These were conducted for three days (one weekend and two weekdays), at Shahdara Mor and KSK Interchange. It was estimated about 11,774 for through traffic from KSK to Shahdara, for through traffic from Shahdara to KSK 14,681 and total through traffic between KSK and Shahdara was estimated 26,455. Out of these 13,113 were Qingqis. It shows that this mode is the most used mode in the study area. Also 89% of Qingqi users were willing to shift to MBS proposed extension.

3.1 Sample Characteristics

The user perception survey showed that most of the individuals belong to lower middle group having monthly income in the range of Rs. 5000 to Rs. 20,000 per month. Share of such respondents were observed to be around 51 percent from the sample collected using SPSS. Motorcycle is owned by about 35 percent individuals. It clearly shows that this mode is very common and most of the people prefer to use it as compared to other modes.

Majority of the individuals of the study area works in private sector about 48 percent, while the representation of students is second highest about 17 percent. This shows that the commuters travelling on the proposed corridor are mostly either working

in private sector or are students.

When studying the modal split by the trip purpose, for work trips, majority of the people are using Qingqi and only minority group are using private car and auto-rickshaw. For educational trips, the usage of Qingqi is highest again about 46.5%.

Comparing the public transport (auto-rickshaw, Qingqi, mini-bus and bus) users with their household availability, about 66 percent of them can be considered as captive travellers of public transport with no vehicle ownership. As vehicle ownership increases, the chances of using public transport also decrease. The vehicle owned in a household is used by the head of the household in the most of the cases while remaining members rely on the public transport.

3.2 Attitude towards Lahore MBS

A user perception survey was conducted at Shahdara Station of Lahore MBS to assess perception of MBS users. It was found that 83% users were satisfied with punctuality of MBS. About 88.5% agreed that

MBS is safe and 65% said that MBS is affordable. Around 39% MBS users prefer MBS over private / conventional PT because of its accessibility. The Fig. 3 shows the attributes which attracted conventional PT / private vehicle users towards MBS.

Further, it was found that 45% passengers use MBS for work trips. About 97% agreed that MBS should be extended to KSK. Around 23.6% and 23.0% are willing to pay an additional fare of Rs. 5 and Rs. 10 respectively in case MBS is extended from Shahdara to KSK.

3.3 Model for Qingqi

Using stated preference approach, user perception interview survey was carried out in the study area. As the commuters state their preference after perceiving cost of travel, travel time and travel comfort etc. The variables used for the binary logistic model are the proposed extended MBS attributes and the current travel choice attributes as given in Table 1.

Table 1. Input variables.

Variable	Description
Travel Time (TT)	Total travel time for the trip (Walk time to MBS stop + In-vehicle Time)
Travel Cost (TC)	Total cost of the one way trip
Trip Length (TL)	Distance from origin to destination for Home work trips or Home Education trips
Income Group (IG)	Individual Monthly Income
*Traveler's Occupation (TO)	Occupation of a person – 0: Dependent, 1: Independent
ASC	Alternative (Mode) Specific Constant

*Traveler's occupation consists of two categories; dependent includes students, housewife and jobless while independent includes government job, private job, business and labour.

Table 2. Model results in SPSS.

Independent Variable	Estimate (B)	Standard Error (S.E.)	Sig. (Z)	P-value
TO	-0.199	0.665	0.764	0.819
IG	0.000	0.000	0.017	1.000
TL	0.246	0.119	0.039	1.279
TT	-0.164	0.049	0.001	0.849
TC	0.036	0.062	0.558	1.037
ASC	4.784	1.498	0.001	119.566

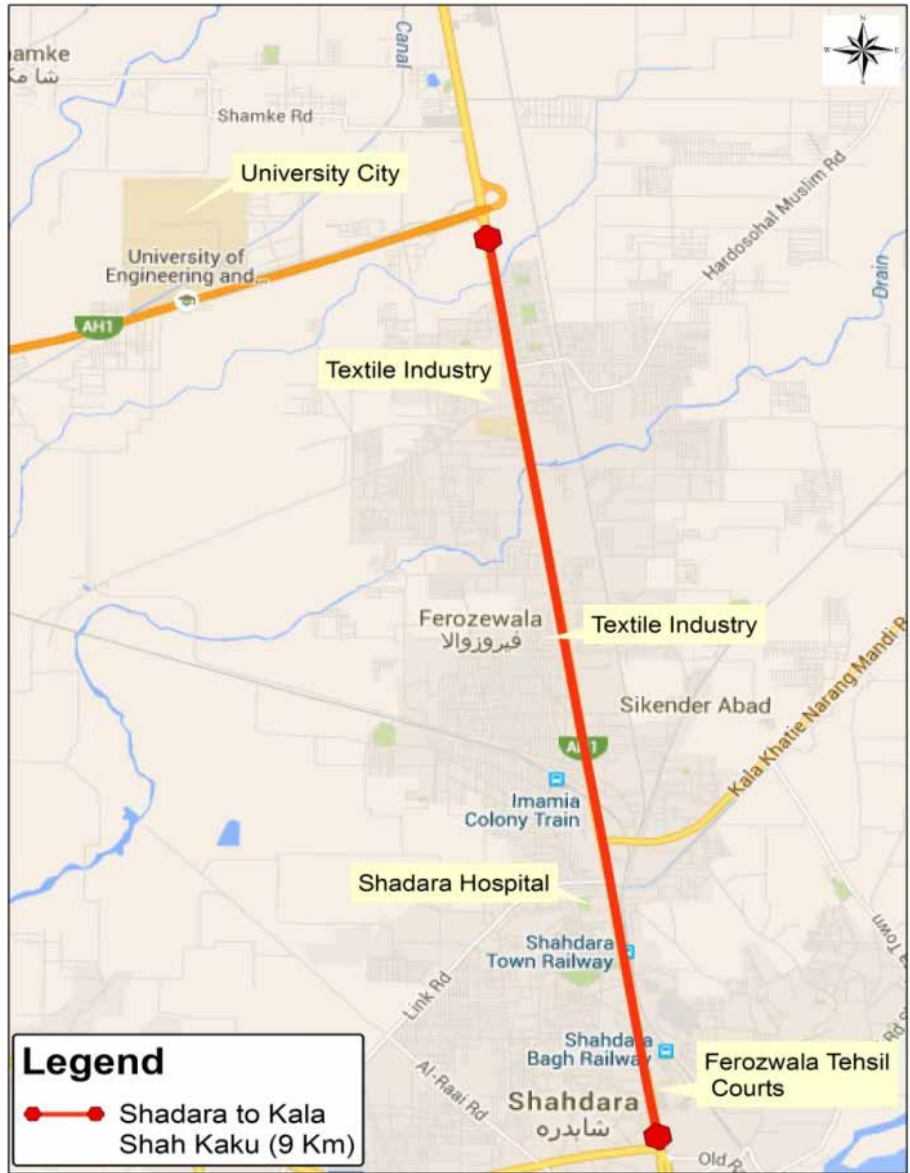


Fig. 1. Location map of the proposed extended metro bus corridor.

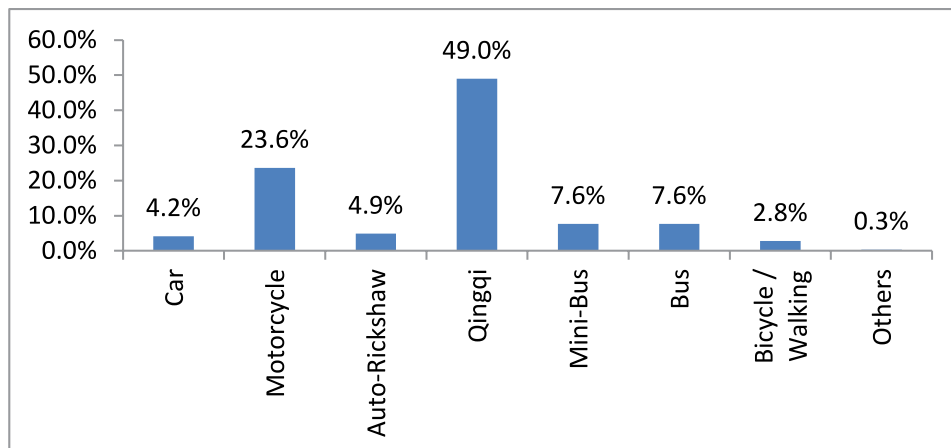


Fig. 2. Existing mode of travel in study area.

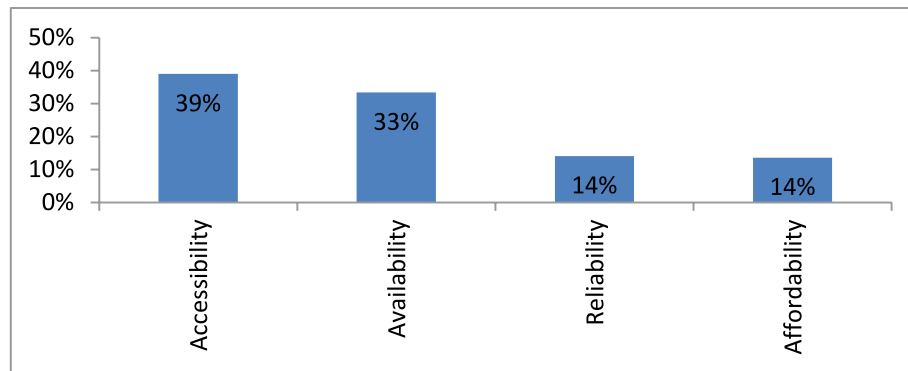


Fig. 3. Attributes that caused modal shift to MBS.

The binary logit analysis was employed to model the attributes and preferences of the commuters through their stated choices. The utility functions, derived out of the choice sets help to observe the relative attractiveness of each alternative, for a given trip. The contribution of each attribute to a utility of an alternative is indicated by the sign of its coefficients. A positive value indicates a positive impact on the utility and opposite applies to negative value. The correlation of various attributes was analyzed in SPSS. Depending upon the value of regression coefficient selection of the attribute / choice set was done for derivation of utility equation.

The inclusion and exclusion of the variables is dependent on their significance test. If the parameter of a variable is giving very low significance test results, they are excluded. Based on this theory various models were developed which are described below.

The utility expression was used to determine the total utility of the MBS in comparison with Qingqi. In this case a high utility value indicates that the commuters preferred the MBS more and thus the MBS will be more attractive to its potential users. On the other hand, a lower Utility value indicates that the commuters preferred the MBS less meaning that the MBS will be less attractive to its potential users i.e. the commuters.

$$U_Q = ASC + (\beta_O \times \text{Occupation}) + (\beta_{MI} \times \text{Monthly Income}) + (\beta_{TL} \times \text{Trip Length}) + (\beta_{TC} \times \text{Travel Cost}) + (\beta_{TT} \times \text{Total Travel Time})$$

Here, β_O = Utility parameter for Occupation

β_{MI} = Utility Parameter for Monthly Income

β_{TL} = Utility Parameter for Distance Travel

β_{TC} = Utility Parameter for Travel Cost

β_{TT} = Utility Parameter for Travel time

ACS = Alternative Specific Constant

Nagelkerke R-square 0.315

Cox and Snell R-square 0.155

The estimated logit is obtained from the following equation:

$$U_Q = 4.784 - (0.199 \text{ Occupation}) + (0.246 \text{ Trip Length}) - (0.164 \text{ Total Travel Time}) + (0.036 \text{ Travel Cost})$$

This utility function derived out of the choice sets, helps to assess the relative attractiveness of the option, indicated by the sign of the coefficients of the attributes. Qingqi is the most accessible and cheaper mode of public transport in Pakistan but its design is not proper. This mode is causing noise and air pollution. Also it is involved in majority of accidents in Lahore city. The drivers of Qingqi mostly belong to poor families and uneducated. There is no provision of side mirrors in this mode which is a major flaw.

The models developed of other modes of transportation i.e. bus, auto-rickshaw, car and wagons showed that trip cost is the most significant factor for mode choice. The model for Qingqi shows that the monthly income, travel distance and total travel time are the most significant parameters, in order to encourage the modal shift. The results show that commuters prefer the use of Qingqi as public transport because of its lesser travel time

and cheaper cost. Modal shift of this mode can be achieved more than 90% by providing a service like metro bus which has good quality service, lesser travel time and low fares too. In developing countries like Pakistan, commuters prefer cost of travel over time and comfort because of lower household income. However, this pattern is in contrast with developed world where commuters give maximum value to travel time.

4. CONCLUSIONS

The conclusions of this study were as under:

- Most used PT mode in this corridor is motorcycle rickshaw / Qingqi and it has the highest modal shift possibility of 89%.
- Total travel time is found to be the most significant attribute in modal shift to MBS.
- Income of the commuters of study area has no effect on the modal shift as mostly Qingqi users belongs to lower middle income group
- Trip length has a positive coefficient, shows that for longer trips modal shift towards MBS is expected to be higher
- Travel cost has small estimate value as the cost of Qingqi and proposed MBS is same. It doesn't have much effect on modal shift in the study area.

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