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Mode Shift Behavior of Commuters Toward Islamabad Metro Bus Service

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Abstract

Purpose: Transportation is considered the fundamental factor for mobility as every individual is highly dependent on transportation so that they can access work, goods, and other services. Increasing demand for motorization will bring up a congestion issue, especially in growing urban communities. Islamabad, the capital city of Pakistan, along with its neighboring city Rawalpindi has initiated a metro bus service to ease its traffic congestion problem and reduce atmospheric pollution. This study aimed to analyze the mode shift behavior of commuters from public transport, own transport, and taxi after the implementation of the metro bus service.

Design/methodology/approach: We employ logistic regression in our study because mode shift behavior is binary in nature.

Findings: The results of our study indicated that, in general, commuters are more willing to shift towards metro buses for job and education purposes, and female travelers are more willing to use the metro bus service as compared to males. Income shows no effect on mode shift behavior. We also find that the metro bus has the potential to reduce travel costs by PKR 2369 on average for own transport and PKR 800 for public transport users. Lastly, our findings include that the metro bus service has the potential to clean the environment by reducing carbon emissions, as it replaced approximately 700 public vehicles from the route, resulting in the reduction of around 8000 metric tons of carbon emissions from the region.

Originality/value: All our findings are original and new in the literature.

Practical Implications: Our findings imply that many commuters are willing to shift towards metro buses for job and education purposes, especially for female travelers, regardless of their income levels. Our findings are useful not only for commuters, but also for metro companies for their plan for the development of their companies and for Governments to carry out more policies to encourage more commuters to shift towards metro service to reduce traffic jams and pollution and useful in their city planning.

Keywords: Own transport; Public transport; Mode Shift Behavior Metro Bus Service; Travel cost; Logistic Regression

JEL Classifications: D04, D12, D23,N70, R41

Paper Type: Research Paper

Introduction

Rapid urbanization in developing nations is causing many rural citizens to migrate towards urban areas to explore job opportunities and for better facilities. Along with urbanization, transportation is also increasing instantly because it is considered as the fundamental factor in urbanization. Every individual is highly dependent on transportation as it provides mobility to the population so that they have access to jobs, markets (goods and services), and what they need and want. Increasing demand for motorization is causing congestion issues in quickly growing urban communities (Un-Habitat, 2012). Subsequently, congestion is a noteworthy issue, a lot of time is wasted in traffic as well as the emanation of carbon dioxide. The transport sector is responsible for around 25% of global carbon dioxide (CO2) emissions. Like many other urban cities in Asia, Islamabad, the capital city of Pakistan, is considered the third biggest urban amalgamation in Pakistan having a 4.5 million population, facing a prominent growth in population and vehicles too. People travel to Islamabad for jobs and other economic activities on a daily basis from the neighboring cities such as Rawalpindi, Taxila, and Hasanabdal, which results in the increased reliance on personal vehicles. The main mode of mobility between the cities is only through private transport as there was no public bus or rail system. Around 525,000 passengers are carried by over 210,000 vehicles on three major corridors of the cities (Asian Development Bank, 2012). During the last couple of years, there has been an exceptional increment in vehicular activity, so the Federal government in collaboration with the Punjab metro bus authority launched a bus rapid transit (BRT) system in June 2015 in the Rawalpindi-Islamabad region.

The ownership of a car in developing countries, particularly in the Asian context, is considered as the status, comfort, self-respect, and privacy of the high-income travelers whereas motorbike is considered as high accessibility even in peak times, therefore, the shift from private to public transit system is cognitive in nature. The objective of this study is to assess the mode shift behavior of commuters (own transport) to BRT service in Islamabad, Pakistan by applying the stated preference method.

Literature Review

The consumer choice theory reveals that travelers maximize their utility about the mode of travel based on experience, perception and other attributes of all available options. The probability of an alternative traveling mode being selected by the travelers or how they behave among different choices has been analyzed in utility-based models by differentiating the actual and expected utilities of the attributes through the stated preference method (Chakrabarti, 2017)).

The literature reveals that Bus Rapid Transit (BRT) has both economic and social incentives for commuters in terms of cost-saving, affordability, network coverage, flexibility, and comfort as well as improve save the environment by reducing carbon emission and congestion. The studies on BRT in different cities of developed and developing countries significantly improve the environment, for example, BRT in Tehran save 6.5 million liters of fuel annually and improve the road congestion as 29,450 taxis left the route, in Delhi, the carbon emission reduces by 2.3%, Bogota reduces one million tons of carbon emission and around 40,000 carbon emission are reduced annually in Johannesburg, while 167 tons of carbon emissions are reduced daily in Istanbul (Alpkokin and Ergun, 2012).

Elasticity is related to mode choice have shown that passengers who use metro bus service are oversensitive to changes in travel cost as compared to the travel time this paper has evaluated the elasticity of demand for public transport and found that traveler demand has diminished by 3.9 percent for a 10 percent expansion in travel time, while demand has decreased by 7 percent for each of the 10 percent increment in egress, waiting time, and access (Domencich and McFadden, 1975). These discoveries were accounted for and approved later by another study and have found in the study that passengers of metro bus service in Athens are quite sensitive to changes in travel costs than travel time. From a ridership viewpoint, the metro bus system in Athens has pulled in 53% of transport riders and 24% of private transport users (Golias, 2002).

The behavior of commuters is inelastic in nature as personal characteristics (habit, taste, culture, lifestyle, and physical attributes) remain constant but external factors (availability of choice,

networks) and internal factors (time, cost, and purpose) have a positive impact on commuter's behavior. It has been examined the mode shift behavior of different transport users (auto, taxi, bicycle, and bus) after the implementation of the metro bus system in Xi'an, China, and found that 20.6% of the passengers were using private transportation before the launch of the metro bus. However, normal bus users were insensitive to travel time, and travelers having a higher level of income prefer to use taxis (Wang, et al., 2013). Another study analyzed the mode shift behavior of car travelers to bus service found that age, gender, the purpose of making a trip, and difference in time are major factors that affect the mode shift behavior of travelers and among those, mode shift for work purpose was quite large (Vedagiri and Arasan, 2009). It has been estimated that the travel mode choice of students for car and public transport, concluded that factors like travel time, number of cars owned, and parking access show significant effects on mode shift behavior of students (De Guzman and Diaz, 2005).

Based on several other studies, the factors affecting traveler mode choice behavior in the transportation sector may differ because of different trip purposes. Socioeconomic characteristics such as age, gender, income level, car ownership per adult, and trip characteristics such as travel cost, travel time, travel distance, level of service, and frequency are considered to be the significant factors that have a major impact on travelers' mode shift response.

Study Area

This research is carried out for the metro bus service located in twin city, Islamabad (capital), and its adjoining city, Rawalpindi. Together, both cities are considered to be the third biggest urban amalgamation in Pakistan having a 7.7 million population (Pakistan Bureau of Statistics, 2015). The main mode of mobility between the cities is only through private transport and around 525,000 passengers are carried by over 210,000 vehicles on three major corridors of the cities. It is estimated that over 700,000 daily trips are taken within Islamabad, including 500,000 daily trips to and from Rawalpindi alone (Asian Development Bank, 2012). In order to trap the serious issues in the city such as road congestion and increased rate of air pollution, The Federal Government in collaboration with the Punjab Government launched a bus rapid transit system in June 2015 in the Rawalpindi-Islamabad region. It is 22.5 kilometers in length with 24 stations in the corridor starting from Pak. Secretariat and ends at Saddar, Rawalpindi. The total number of stations in

Rawalpindi is 10. (8.6 km), while on the other hand, the total number of stations in the Islamabad part is 14 (13.9 km). It carries 125,000 passengers on a daily basis (Pakistan Metro Bus System, 2016).

Metro bus provides several benefits which include reduced motor vehicle accidents, savings in operating costs and travel time, and will help make a superior urban condition by reducing congestion and pollution and help the low-income communities residing in twin cities, especially women, elders, and disadvantaged people by charging PKR 20 for each trip. The aim of this study is to examine the mode shift behavior of passengers from their previous modes such as public transport, own transport, and the taxi after the introduction of the metro bus service in the city.

A primary survey is conducted in order to analyze the commuters' perception regarding the use of the metro bus service. The data is collected from commuters by using questionnaire-based surveys in the months of February, March, and April 2017 from various stations of the metro bus. Data is collected from different stations of the metro route during weekdays, weekends, peak hours, and off-peak hours. The time of the visit to stations during peak hours was 7:00 am to 10:00 am in the morning and 3:30 pm to 6:30 pm in the evening and the survey conducted during operation hours was 11:00 am to 2:00 pm and 7:00 pm to 8:00 pm (off-peak hours). The sample selection according to a formula with a 5% error term from 125,000 daily passengers of the metro bus is 360, but to avoid any incomplete information, a total of around 445 samples were finalized from the study area with a response rate of ninety-two percent (92%).

Model and variables

The logistic regression is used when the dependent variable is binary in nature (e.g. yes vs. no). The mode choice model assumes the commuters choose that mode that has maximum utility (Chakrabarti, 2017). The study used mode choice of metro vs. vehicle (own Car and own Bike and Taxi) as the dependent variable for a home-to-a-work trip, home-to-shopping trip, and home-to-education trip.

The dependent variable behavior i.e. mode choice of transit explanatory variables includes the purpose of visit, gender, income, distance, travel cost, and travel time. The general form of the model is:

$$Y_i = \beta_0 + \beta_1 X_i + \mu_i \ , \qquad (1)$$

where Y_i is a dichotomous variable that is equal to 1 if using metro and 0 if ownership (car, bike, taxi), β_0 is the constant term, β_1 is the coefficient of the explanatory variable, and μ_i is the error term.

The estimated probability of mode choice used in our paper is:

$$P(Y = 1|X = x) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_i)}} , \qquad (2)$$

in which all the terms are defined in Equation 1. The explanatory variables for mode choice or shifting from own vehicle to metro used in this study are gender, family income, distance, travel cost, and travel time for a purpose. The purpose is divided into the following categories: job, education, shopping, hospital, friend and family visit, and social activities. The explanatory variables are described in Table 1 while the descriptive statistics of explanatory variables are in Table 2.

Table 1: Description of Explanatory Variables

Variable	Measurement	Description
Distance	KM	This variable is defined as the distance between the start of the journey and destination of respondents.
Travel Cost	PKR	The total amount of travel cost which is borne by the passengers is taken as a major variable in the model
Travel time	Minute	The total amount of time spent during travel by passengers is also taken as a major variable in the model
Gender	Binary	Male prefer more metro as compare to females, for gender between the male and female groups. Where male =1, else, 0
Income	PKR	The income of respondents included in the model to estimate the income effect on different mode choices.
Education	Year of schooling	The education variable includes the education level of respondents. It varies from illiterate to 20 years of education.
Purpose	Categorical variable	Purpose means the reason for using the metro bus. There are 3 purposes i.e. job, education, shopping.

Emprical Analyhsis

Description Statistics

Initially, the study summarizes the gender-based trip purposes of metro bus users as shown in Table 2. It shows that 47% of trips are for jobs and education made by both males and females and it is very obvious that most of the offices are located in Blue Area in Islamabad, Pakistan. Similarly for shopping purposes people rich out the big shopping mall or such areas where the goods are available at lower prices. The statistic shows that 15.73% of the total population use the metro for shopping purposes and interestingly the male ratio is more than female i.e. 8.09%. Health is also a very important component and many hospitals are located in these areas where these bus stations are near to them. A total of 10.56% of the population used metro services for health purposes and amount this population the female ratio is more than male i.e. 7.42% and 3.15% respectively. It also indicates that's females alone travel on metro buses to reach out to the health care units. The services are also used for socializing such as getting together with friends and family and hangouts. The statistics show that 13.93% of the total population used the metro to reach out there friends and 11.91% for social activities. In both cases, the male dominancy is there in Table 2 as shown. The overall male ratio is more than the female ratio i.e. 55.96% and 44.04% and it shows that males are most frequent users of both metro and bus services.

Table 2: Gender Base Trip Purpose of Metro Bus Users

Gender	Job	Education	Shopping	Hospital	Friend	Social	Total
Female	12.58	11.46	7.64	7.42	1.35	3.60	44.04
Male	12.13	11.69	8.09	3.15	12.58	8.31	55.96
Total	24.72	23.15	15.73	10.56	13.93	11.91	100

Note: all variables have been defined in Table 1. All figures are in %.

As shown in Table 3, it tends to highlight the socio-economic variable such as age, income, education, and occupation of the population. Most of the respondent ranges from 15 to 56 years and their mean age is about 25 years which means that most of the young respondents are of young age who use the BRTs. Most of them are going to the educational institute and offices. The mean income of the respondents is about 59,000 PKR which shows that the middle-income respondent

is using the BRT services and it is very obvious because the metro bus service is linked with govt. offices and higher education. The education level of respondents varies from illiterate to 20 years of education. The mean education level is 12 and 14 years of education. 40.19% of the respondents have 14 years of education. Both 12 years and 16 years of education constitute around 61.6% of the total sample size. Most of the travelers are students (62.71%), government employees (6.49%), and private-sector employees (9.83%).

Table 3: Summary Statistics of Socio-Economic Variables

Variables	Min	Max	Mean	S.D
Age	15	56	24.957	7.30
Income	5000	300000	58871.922	29393.15
Education	1	20	13.8	1.36
Occupation	1	10	2.623	2.70

Note: all variables have been defined in Table 1.

Travel cost reduction and travel time reduction is one of the most important that decided the use of to metro bus service. The descriptive statistics of the two factors show that the travel cost has been reduced by about 801 PKR while the time saved by the travelers using the metro is 24 minutes shorter than those using other public transport. The reason for this reduction in costs is because of not frequent changes in bus stops and fairs. Own transport users have saved on average PKR 2269 monthly, by shifting their travel mode to the metro bus. Similarly, taxi users also saved PKR 1091 on monthly basis by converting travel mode to a metro bus.

In terms of travel time reduction, public transport users stated that an average of 24 minutes is saved by using the metro bus, whereas, for own transport users, an average of 20 minutes is reduced. Similarly, an average of 25 minutes is saved for each trip of taxi users. The reason is the metro bus has a separate route, while there is a lot of traffic on other roads, which is the major cause of traffic congestion, due to which a lot of time is consumed on roads (see Table 4).

Table 4 Travel Cost and Time Reduction

Mode of transport change	Travel Cost Reduction (PKR)				Travel Time Reduction (Mints.)			
	Min	Max	Mean	S.D	Min	Max	Mean	S.D
Public Transport	10	3800	801.21	-773.38	10	60	23.78	-12.04
Own Transport	100	8800	2268.98	-2473.06	10	45	20.21	-5.65
Taxi	260	2960	1091.29	-671.7	15	50	25.23	-9.72

Note: all variables have been defined in Table 1.

Logistic Regression Models

The study aims to analyze the mode shift behavior of public transport, own transport, and taxi users after the implementation of the metro bus service. Three purposes such as job, education, and shopping have been used for mode shift behavior separately along with explanatory variables of gender, income, distance, travel cost, and travel time.

Transport Shift for Job Purpose

The logistic regression results are shown in Table 5 when the dependent variable is job purpose. This table exhibits the mode shift behavior of public transport, own transport, and taxi users after the introduction of the metro bus for job purposes.

The results show that males have15.3% greater odds to shift to the metro bus service for job purposes. The regression estimate of distance is 0.102, which implies that as distance increases, the likelihood of public transport users shifting to the metro bus increases by 1.108 units. Further, it indicates that each additional kilometer increase in distance increases the log odds of shifting towards a metro bus by 10.8% for job purposes. Notably, the regression coefficient of travel time is positive and significant, indicating that travel time increases the probability of travelers shifting to the metro bus by 1.049 units. Travel time plays a vital role for those who travel for their jobs. The logistic estimate of gender is -0.136, showing that male travelers are less willing to shift their mode of travel to the metro bus as compared to females for shopping purposes. The probability of male travelers shifting to the metro decreases by 12.8%.

Trip cost also shows significant results for the mode shift to the metro bus service. The regression coefficient is positive and significant at the 0.01 significance level, indicating that trip cost increases the probability to shift to the metro bus service by 1.001 units. As the travel cost of public transport increases, the likelihood to travel by the metro bus service increases by 0.1%. The lower travel cost of the metro attracts the lower and middle-income groups to shift their travel mode from public transport to the metro bus.

Own Transport

The regression estimate of distance is 0.323, which implies that as distance increases, the likelihood of own transport users shifting to a metro bus increases by 1.382 units. Further, it indicates that each additional kilometer increase in distance increases the log odds of shifting to a metro bus by 38.2%. Trip cost also shows significant results for the mode shift towards the metro bus service. The regression coefficient is positive and significant at the 0.01 significance level, indicating that trip cost increases the probability to shift to the metro bus service by 1.004 units.

As travel costs by own transport increase, the likelihood to travel by metro bus service increases by 0.1%. the lower travel cost of the metro attracts the lower and middle-income groups to shift their travel mode from public transport to the metro bus.

The logistic regression coefficient of travel time is positive and significant, indicating that travel time increases the probability of travelers shifting to the metro bus by 0.907 units. Travel time plays a vital role for those who travel for job purposes. As travel time increases, the likelihood to travel by the metro bus service increases by 9.3%.

Taxi Services

All the explanatory variables are statistically significant except income which is an insignificant variable. The logistic estimates for gender are -0.492, which indicates that male travelers are less willing to travel by metro as compared to female travelers. It further exhibits that males have 38.9% greater odds of using the taxi as compared to the metro bus. Like the above two models, income has no impact on taxi travelers.

The logistic regression coefficient of distance is 0.111. It is positive and statistically significant. The odds ratio of the distance variable explains that a 1-kilometer increase in the distance leads to a 1.118 units increase in the likelihood to shift to the metro bus. The percentage of this shift towards the metro is 11.8%.

The logistic estimate of travel costs is 0.005. This variable is statistically significant at zero significance level. In terms of percentage, as the travel cost of taxis increases, the log odds for mode shift towards the metro bus increases by 0.1%. Likewise, travel time is also statistically significant at the 0.003 significance level. The logistic coefficient of this variable is 0.034. As travel time increases, the likelihood to shift towards the metro from taxi mode increases by 3.6%.

Table 5: Logistic regression Model for Job Purpose

	Public Transport			**Own Transport**			**Taxi service**		
Variables	**B**	**Odds Ratio**	**%**	**B**	**Odds Ratio**	**%**	**β**	**Odds Ratio**	**%**
Gender	0.141	1.152	15.3	-2.427	0.088	-91.2	-0.492	0.611	-38.9
	(-0.712)			(-0.001)			(-0.04)		
Income	0	0.999	0	0	1	0	0	1	0
	(-0.019)			(-0.015)			(-0.94)		
Distance	0.102	1.108	10.8	0.323	1.382	38.2	0.111	1.118	11.8
	(-0.002)			(0.0)			(0.00)		
Travel Cost	0.001	1.001	0.1	0.001	1.004	0.1	0.005	1.0004	0.1
	(0.00)			(-0.01)			(0.00)		
Travel Time	0.048	1.049	4.9	0.097	0.907	9.3	0.034	1.035	3.6
	(-0.002)			(-0.019)			(-0.003)		
Constant	-3.358	0.034		-3.409	0.033	.	-3.272	0.037	
	(0.00)			(-0.02)			(0.00)		
Observations	223			114			108		
Pseudo R^2	0.2631			0.4805			0.2444		

Note: all variables have been defined in Table 1. t-values are in parenthesis.

The results indicate that there is a 26% variation independent variable is explained by the explanatory variables whereas the metro-own model shows a 48% variation in the model that can be explained by the explanatory variables. On the other hand, the metro-taxi model shows that there is a 24% variation in the model is explained by explanatory variables (Table 4). Income has no impact on mode shift behavior, which means when income increases by 1%, then there is no change in mode shift from public transport to the metro bus.

Transport Shift for Education Purpose

Public Transport

The results show that males have 72.9% greater odds to travel by their existing modes and they are not willing to shift towards the metro bus. Income has no impact on mode shift behavior. When distance increases, the likelihood of public transport users shifting towards the metro bus increases by 0.840 units. Further, it indicates that each additional kilometer increase in distance increases the log odds of shifting towards a metro bus by 15.9%.

Trip cost also shows significant results for mode shift towards the metro bus service for educational purposes. The regression coefficient is positive and significant, indicating that trip cost increases the probability to shift to the metro bus service by 1.001 units. As travel cost increases, the likelihood to travel by the metro bus service increases by 0.1%. The lower travel cost of the metro attracts the lower and middle-income groups to shift their travel mode from public transport to the metro bus.

The estimate of the travel time is positive and significant, indicating that travel time increases the probability of travelers shifting to the metro bus by 0.926 units. As travel time increases, the likelihood to travel by the metro bus service increases by 7.3% (table 6).

Own Transport

The mode shift behavior of own transport users after the introduction of the metro bus. The results show that males are less willing to shift towards the metro bus and continue using their own transport i.e. -0.197. In terms of percentage, males have 17.9% greater odds of using their

previous mode of travel as compared to females. Again, Income has no impact on mode shift behavior for education purposes.

As the distance increases, the likelihood of own transport users shifting towards the metro bus decreases by 0.968 units. The coefficient of distance is negative for own transport mode, which means that own transport travelers are not willing to shift to the metro mode and continue their existing mode and it indicates that each additional kilometer increase in distance decreases the log odds of shifting towards the metro bus by 3.2%.

Trip cost also shows significant results for the mode shift towards the metro bus service. The results indicate that trip cost increased the probability to shift to the metro bus service by 0.98 units. As travel cost increases, the likelihood to travel by the metro bus service increases by 0.2%. The lower travel cost of the metro, i.e., 20PKR for a single trip attracts the lower and middle-income groups to shift their travel mode from public transport to the metro bus. The coefficient of travel time is positive and significant, indicating that travel time increases the probability of travelers shifting to the metro bus by 1.04 units.

Taxi Services

The estimates that male travelers are less willing to travel by metro as compared to female travelers i.e. -0.314. It further exhibits that males have 27% greater odds of using the taxi as compared to the metro bus. Like the above two models, income has no impact on taxi travelers.

The coefficient of the distance variable is negative and statistically significant. The odds ratio of the distance variable explains that a 1-kilometer increase in the distance leads to a 0.956 unit decrease in the likelihood to shift to the metro bus. It further indicates that the log odds of shifting to the metro bus decrease by 4.4%, if the distance increases by 1 kilometer.

The travel cost variable is statistically significant. In terms of percentage, as travel cost increases, the log odds for mode shift towards the metro bus increase by 0.1%. Travel time is also statistically significant at 0.04. As travel time increases, the likelihood to shift towards the metro from taxi mode increases by 2.5%.

Table 6: Logistic Regression Model for Education Purpose

	Public transport	Own transport	Taxi Services

Variables	B	odds Ratio	%	B	Odds Ratio	%	β	Odds Ratio	%
Gender	-1.31	0.27	-72.9	-0.197	0.82	-17.9	-0.314	0.729	-27
	(-0.001)			(-0.7)			(-0.58)		
Income	0	1	0	0	0.999	0	0	0.999	0
	(-0.03)			(-0.001)			(-0.52)		
Distance	0.174	0.84	15.9	-0.032	0.968	-3.2	-0.045	0.956	-4.4
	(0.00)			(-0.4)			(-0.1)		
Travel Cost	0.004	1.001	0.1	0.002	0.98	0.2	0.005	1.0004	0.1
	(-0.07)			(-0.1)			(-0.02)		
Travel Time	0.076	0.926	7.3	0.038	1.04	3.9	0.025	1.025	2.5
	(-0.001)			(-0.03)			(-0.04)		
Constant	1.486	0.034	.	1.93	6.941	.	0.116	1.123	
	(-0.03)			(-0.11)			(-0.92)		
Observations	223			114			108		
Pseudo R^2	0.2868			0.1947			0.266		

Note: all variables have been defined in Table 1. t-values are in parenthesis.

There is a 28.6% variation in the model is explained by the explanatory variables while the metro-own transport model shows a 19% variation is explained by explanatory variables in the model. Similarly, the metro-taxi model shows a 26.6% variation that is explained by explanatory variables (Table 6).

Transport Shift for Shopping Purpose

Public Transport

The results show that male travelers are less willing to shift their mode of travel towards the metro bus as compared to females i.e. -0.136. The probability of male travelers shifting to the metro decreases by 12.8%. Income has no effect on shift mode, but here it shows an inverse association between income and shifts towards the metro bus when the purpose of travelers is shopping. It means that with an increase in income, the probability to shift to the metro bus decreases (Table 7).

The results show a positive relationship between distance and mode shift behavior as shown by the coefficient of distance. The odds ratio of distance explains that a one-kilometer increase in the distance leads to a 0.959 unit increase in the mode shift behavior of public travelers towards the metro bus, whereas in terms of percentage, with additional kilometer increase in distance, increases the log odds to shift towards metro bus increases by 4%.

The estimate of travel costs in the metro-public mode is 0.003. Reduced cost of metro attracts the passengers of other modes by 0.1% for shopping purposes, whereas the odds ratio of this variable indicates that with 1 PKR increase in travel cost leads to 0.999 units increase in mode shift behavior towards metro bus service.

Correspondingly, travel time has an estimate of 0.01 and is significant at a 0.05 significance level. The odds ratio of this variable indicates that each additional minute of travel time spent on public transport leads to the increased likelihood to travel by metro by 1.001 units.

Own Transport

In explaining the gender variable, the estimate of this variable is -0.298, which indicates that male travelers are less willing to shift their travel mode to the metro bus for shopping purposes as compared to female travelers. In terms of percentage, there is a 25.8% decline in the mode shift behavior of male travelers.

In this case, income again has no impact on mode shift behavior, but its coefficient reveals a negative association with the mode shift. It means that as the income of travelers tends to increase, the probability of shift towards the metro bus service decreases, and individuals continue to travel by own transport. It is quite obvious from this result that high-income individuals are not attracted by the low fare of the metro bus service.

Distance has a coefficient of 0.052, which shows a positive association with mode shift to the metro for own transport users. The odds ratio of distance interprets that a one-kilometer increase in the distance leads to a 0.949 unit increase in the likelihood to shift towards the metro bus service. Furthermore, the log odds to shift to the metro have been increased by 5.1%.

The regression coefficient of the travel cost variable is 0.005 and it is statistically significant at the 0.01 significance level. Moreover, it illustrates that the low cost of the metro attracts the own

transport travelers by 0.1% for shopping purposes, whereas the odds ratio of this variable indicates that with 1 PKR increase in cost reduction leads to 0.999 units increase in mode shift behavior towards metro bus service. Likewise, travel time has an estimate of 0.01 and is significant at a 0.05 significance level. The odds ratio of this variable indicates that each additional minute spent on travel time for own transport leads to the increased likelihood to travel by metro by 0.989 units.

Taxi Services

Starting from the gender variable, the estimate shows that male travelers are less willing to change their travel mode from taxi to metro bus as compared to female travelers. The probability of male travelers shifting to the metro decreases by 12.8%, while the P-value shows that this variable is significant at a 0.05 significance level.

The estimate of the distance variable is 0.095. It shows a positive association with the mode shift to the metro bus. The result of the odds ratio can be interpreted as the mode shift behavior towards the metro bus will be increased by 0.909 units for each additional kilometer increase in distance.

It further explains that if the distance increases by one kilometer, then the log odds for shifting towards metro mode from taxi mode increase by 9.1%.

The estimate of travel costs is statistically significant. In terms of percentage, as travel increases, the log odds for mode shift towards the metro bus increases by 0.1%. Travel time is also statistically significant at the 0.1 significance level. The logit coefficient of this variable is 0.969. As travel time increases, the likelihood to shift towards the metro from taxi mode increases by 3%.

Table 7: Logistic Regression Model for Shopping Purpose

	Public Transport			**Own Transport**			**Taxi Services**		
Variables	**β**	**odds Ratio**	**%**	**B**	**Odds Ratio**	**%**	**B**	**Odds Ratio**	**%**
Gender	-0.136	0.872	-12.8	-0.298	0.742	-25.8	-1.582	0.204	-79.5
	(-0.643)			(-0.215)			(-0.03)		
Income	0	0.999	0	0	0.999	0	0	0.999	0
	(-0.76)			(-0.301)			(-0.06)		
Distance	0.041	0.959	4	0.052	0.949	5.1	0.095	0.909	9.1
	(-0.01)			(-0.02)			(-0.147)		

Travel Cost	0.003	0.999	0.1	0.005	0.999	0.1	0.002	0.999	0.1
	(-0.08)			(-0.002)			(-0.06)		
Travel Time	0.01	1.001	0.2	0.01	0.989	1	0.03	0.969	3
	(-0.05)			(-0.03)			(-0.08)		
Constant	0.407	1.502	.	1.08	2.94	.	5.175	176.89	
	(-0.41)			(-0.014)			(-0.01)		
Observations	223			114			108		
Pseudo R^2	0.286			0.152			0.217		

Note: all variables have been defined in Table 1. t-values are in parenthesis.

The result also shows that there is a 28.6% variation in the model is explained by the explanatory variables, while the variations are 15% and 21.7% in own transport and taxi service respectively.

Discussions and Concluding remarks

Discussions

This study employs a logistic regression method to analyze the survey data associated with the metro bus service in Islamabad-Rawalpindi, twin cities in Pakistan, and examine mode shift behavior for the shift to metro service for public transport, own transport, and taxi users.

Factors that are statistically significant in affecting model shifts to metro bus service include trip distance, travel cost, and travel time of commuters. From the survey data of the metro bus service, it is found that 18% of metro passengers were former public transport users and their own transport and taxi users together comprised 17%, metro travelers. In the prior studies, the modal shift was 50% from bus and train users and 27% from car users (Knowles, 1996). The new metro in Athens has attracted 53% of bus passengers and 16% of former car travelers (Golias, 2002). In the Madrid subway project, 50% of passengers were former bus users, and 26% of passengers used to travel by car (Monzon and GONZALES, 2000). Finally, 69% of Tramlink passengers were bus users and 19% of passengers were former auto travelers in Croydon (Copley, et al., 2002). The comparisons among Pakistan metro bus and other cities indicate that mode shifts to the newly introduced metro from public transport closely resemble one another. Another interesting finding can be seen from the gender factor with negative signs of gender variable in the overall models indicating that women travelers are more likely to use the metro than men. This conclusion is

inconsistent with Enam and Choudhury (2011) who conclude that female travelers are reluctant to include public transport modes in their choice sets. Income showed no impact on mode shift behavior.

Our study finds a reduction in both travel cost and travel time due to the implementation of the metro bus system. According to our findings, almost PKR 801 to PKR 1091 and travel time of around 23 minutes are reduced, respectively, for metro bus commuters. This conclusion is consistent with some prior research findings, including Domencich and McFadden (1975), Golias (2002), Wang, et al. (2013), and Yazici, et al. (2013). In addition, Satiennam, et al. (2016) found that Bus Rapid Transit (BRT) significantly attract users who used their own vehicles such as bikes and cars. The majority of this shift is founded more on motorcycle users than bike users and it is obvious for them to use because they will maximize their utilities in terms of comfort. There are two factors that affect the choices; that is, travel time and travel cost. Our study also finds that time has a higher value for car users while, on the other hand, travel cost has a significant effect on motorcycle users.

Another study gives practical and logical attributes that affect the mode choice modal for BRTS. It is argued that if the travel cost increase in any of the mode, the demand for that mode will fall automatically. Travel time is one of the important factors to determine the choice of the mode to be used. The reduction in travel time is another important factor that will increase the use of the travel mode in determining the traffic management scheme for synchronizing the existing infrastructure with the proposed one to get a more efficient public transport system (Yadav, et al., 2017). It is not often that people shift their behavior from private to BRT. For example, SOEHODHO and Nainggolan (2005) found that not all the users of public transport shift to the new and better system due to several reasons, including comfort, travel cost, time travel, and other psychological factors. In developing countries, the perception of comfort and flexibility plays a significant role in the model shift (Sarkar and Mallikarjuna, 2018). According to Maunganidze and Del Mistro (2012), the BRT-based IRT system is clearly not beneficial to the poor in urban areas in the context of improvements in service levels. While the poor commuters can benefit from more accessible, frequent, and faster IRT services as well as ironed travel times that will be more expensive and in some cases inaccessible to them and, therefore, it does not provide any benefit

to them. For urban poor users of public transport to reap all the potential benefits of BRT, it is recommended that appropriate measures must be taken to rationalize the BRT-based IRT system.

Policy Recommendations

Our findings can be used to make some important recommendations to policymakers. For example, future expansion of the metro route needs to be implemented to formulate an integrated network within the city. More travel time could be saved by extending the metro route in congested areas. Metro route should be extended in such a way that students and employees can easily reach their respective institutions. Ring Road as constructed in Lahore, should also be constructed in Rawalpindi-Islamabad so that it covers a larger area and more stations of metro bus service can be built on that route. More buses are required in the existing fleet, to reduce the congestion within buses. Moreover, some policies such as the implementation of park and ride facilities may be effective in attracting more passengers from their own transport mode towards the metro bus service. The impacts on easing traffic congestions by a single metro corridor are not significant, and some parallel policies need to be adopted for the support of metro services such as the construction of overhead bridges and underpasses.

Limitation and Future Work

A limitation of this study is that it only surveyed the users of the metro bus service. To circumvent the limitation, non-users of the metro bus service should be included in future studies. Moreover, extensions of our paper could include some land-use variables such as residential density in the model and conduct an economic cost-benefit evaluation to shed more light on the economic feasibility of the metro bus service.

In this paper, we employ logistic regression to examine the mode shift behavior in Islamabad, the capital city of Pakistan. Extensions of our paper could apply our approach to study other transportation problems, see, for example, Bejrananda, et al. (2016), Ho and Puspitasari (2021), Lien, et al. (2020), and Yang, et al. (2019). Scholars could also use our approach to study some tourism problems (Chang, et al., 2020; Mendieta-Aragon and Garín-Muñoz, 2020) and problems of economic policy (Adebayo, et al., 2022; Aye, 2021; Cakan, et al., 2019; Ongan and Gocer, 2017; Ryu and Slottje, 2020; Lv, et al., 2021). Readers may refer to Alghalith, et al. (2021) and Moslehpour, et al. (2021) for other problems that one could apply our approach to study.

Author Contributions

All authors contributed equally

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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