ANALYSIS OF PASSENGERS' TRAVEL BEHAVIORS AND ATTITUDES TOWARDS THE BRT LINE IN ISTANBUL

by

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ABSTRACT

ANALYSIS OF PASSENGERS' TRAVEL BEHAVIORS AND ATTITUDES TOWARDS THE BRT LINE IN ISTANBUL

Rapid increase in population of big cities resulted in a need for a better designed public transportation with higher service quality, which eventually urged authorities to implement fast and cost effective systems. Bus Rapid Transit (BRT) has been designed as one of the most feasible transport systems. This study gives a brief information about the BRT line in Istanbul and investigates the travel behaviors and attitudes of the riders towards the BRT line in Istanbul by conducting a questionnaire. The data collected from 252 respondents. The results demonstrated that the service quality of the BRT line has statistically significant effect on the passenger attitudes towards the BRT line. Respondents rated the BRT line capacity as insufficient. They rated the system on the average 2.18 points over 5 for the capacity sufficiency. 56% of the respondents prefer the BRT line rather for its speed than for the quality of the service provided by the BRT line. Also, the socio-economic characteristics have significant effects on attitudes towards the BRT line. The respondents in the low income levels use the BRT line more frequently than the respondents in higher income levels. The features studied can be considered when improving the BRT line in the future.

ÖZET

İSTANBULDAKİ METROBÜS HATTI İLE YOLCULARIN SEYAHAT DAVRANIŞLARI VE METROBÜS HATTINA KARŞI TUTUMLARININ ANALİZİ

Büyük şehirlerdeki hızlı nüfus artışı sonucunda hızlı, ekonomik, yüksek servis standartlarına sahip ve daha iyi tasarlanmış bir ulaşım modeli ihtiyacı doğmuş ve yetkililerin hızlı ve düşük bütçe ile yüksek performans gösterebilen bir sistem uygulamasını gerekli kılmıştır. Hızlı otobüs ulaşım sistemi en iyi şekilde uygulanılabilen taşıma sistemlerinden biri olarak tasarlanmıştır. Bu çalışma İstanbul'daki hızlı otobüs ulaşım sistemi hakkında kısaca bilgi vermekte ve yolcuların seyahat davranışlarını ve İstanbul'daki hızlı otobüs ulaşım sistemine karşı olan tutumlarını bir anket uygulaması kullanarak incelemektedir. Anket toplamda 252 kişiye uygulanmıştır. Verilerin analizine göre hızlı otobüs ulaşım sisteminin hizmet kalitesi yolcuların seyahat davranışlarını ve sisteme karşı olan tutumlarını istatiksel olarak önemli ölçüde etkilemektedir. Ankete katılanlar özellikle hızlı otobüs ulaşım sisteminin araç kapasitelerini yetersiz olarak değerlendirdiler ve sistemin kapasite değerlendirmesine 5 üzerinden ortalama 2.18 puan verdiler. Ankete katılanların yüzde 56'sı hızlı ulaşım sistemini sağladığı hizmet kalitesinden ziyade sistemin hızı için tercih etmektedirler. Ankete katılan yolcuların sosyo-ekonomik karakterlerinin de hızlı otobüs sistemine karşı olan tutumları üzerinde önemli ölçüde etkisi olduğu sonucuna ulaşıldı. Düşük gelir grubundaki kişiler hızlı otobüs ulaşım sistemini daha yüksek oranda tercih etmektedirler. Bu çalışmaya konu olan özellikler, gelecekte hızlı otobüs ulaşım sistemi geliştirilirken göz önünde bulundurulabilir.

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LIST OF ACRONYMS/ABBREVIATIONS

BRT	Bus Rapid Transit
D 100	D 100 Highway in Istanbul
HRT	Heavy Rail Transit
IETT	Istanbul Public Transport Authority
ITDP	Institute for Transportation and Development Policy Model
ITS	Intelligent Transportation System
IUAP	Istanbul Metropolitan Transportation Master Plan
LRT	Light Rail Transit
PT	Public Transport

1. INTRODUCTION

1.1. Motivation and Problem Description

Limited resources put the authorities in a hard position, which made them obliged to find effective solutions with low initial costs for the solution of heavy congestion in urban areas. Metro and light rail systems are considered as effective solutions; however, their construction periods are long and the cost of these systems are very high (Hensher *et al.*, 2010). Therefore, authorities find alternative solutions with low cost. Bus rapid transit is one such solution. BRT is an example of public transportation, which is easier and more cost effective than the other transportation systems (Hidalgo, 2005). BRT is defined as "a system operating on its own right-of-way either as a full BRT with high quality interchanges, integrated smart card fare payment and efficient throughput of passengers alighting and boarding at bus stations; or as a system with some amount of dedicated right-of-way (light BRT) and lesser integration of service and fares (Hensher and Golob, 2008)". It is a transformable system to the railway system in time which makes it a more attractive and prefereble project.

Due to its lower cost and easy implementation, the Istanbul Metropolitan Municipality decided to open the first BRT line of the country in Istanbul. The Bus Rapid Transit (BRT) line in Istanbul, namely Metrobus, became very popular since its contribution to solve the heavy traffic congestion of the city espically on D 100 Highway. It is opened in 2007 and improved in the following years till today, it has a serious decreasing effect in the travel times and its ridership is increasing continously.

Travel behaviors and attitudes of passengers are important aspects of transportation planning. The attidutes of passengers are important when improving the service quality of a BRT line and planning new projects on that BRT line. The attitudes of passengers towards a BRT line depends on some variables such as features of the BRT line and travel behaviors of the passengers (Curtis and Perkins, 2006).

1.2. Objectives of the Study

The main objective of this study is to evaulate the travel behaviors of passengers and attitudes towards the BRT line in Istanbul by statistically analyzing the answers to the following questions:

- Which features of the BRT line have statistically significant impacts on the attitudes of the passengers?
- How are the travel behaviors affected by the socio-economic characteristics of the passengers?
- Do the socio-economic characteristics of the passengers affect attitudes towards the BRT line?

1.3. Scope and Limitations

This research is aimed to determine the attitudes of passengers towards the BRT line in Istanbul. Only the people living in Istanbul were surveyed. Therefore, the study area is limited by the borders of the city.

Due to time limitations, the survey is conducted mainly on the BRT corridor; hence, the concluding statements may not be a representative of entire population of Istanbul.

1.4. Thesis Outline

- Chapter 2 provides information about the BRT implementations in the world. Then, previous studies on BRT implementations are presented. The chapter also provides some of the previous studies on travel behaviors of BRT riders and their attitude towards BRT systems.
- In Chapter 3, the methodology of the research is presented. The design of the survey, data collection, presentation of demographic information of the respondents and the results of the statistical analysis are provided.

- Chapter 4 includes the conclusions and recommendations for further studies.

2. LITERATURE REVIEW

The literature review chapter is conducted in three main parts providing reviews of BRT implementations in the world, studies for the riders' attitudes towards BRT system and BRT in Istanbul.

2.1. BRT Implementations in the world

BRT system and its implementations have been reviewed many times in transport literature

"A typical BRT system combines exclusive busways technologically-advanced vehicles,upgraded stations, rapid fare collection,advanced Intelligent Transport Systems (ITS) Technologies and a flexible service plan (Deng and Nelson,2012)".

There are 42 countries with active BRT systems in the world. In Europe 56 cities are using BRT system. The number of the cities using BRT line in Asia is 38. Total number of cities having BRT is 189 in the world. The total length of the BRT lines in the world is about 5.000 Km. The number of BRT lines opened since 2001 is 116 (EMBARQ, BRTdata.org). In Table 2.1, some numbers of the BRT systems in the world are presented. According to Table 2.1, Brazil is the city with the maximum number of BRT passengers per day, over 11 millions. Indonesia has the longest BRT network in just one city, namely TransJakarta with 207 km.

Table 2.1. BRT Systems in the World (BRT data.org, EMBARQ, 2014).

Continent	Country	Number of cities using BRT	Length of the Total BRT Line (Km)	Number of Passengers (per day)
Africa	Nigeria	1	22	200.000
	South Africa	2	59	42.000
Asia	China	18	563	3.978.000
	India	8	153	390.000
	Indonesia	1	207	370.000
	Iran	2	148	2.000.000
	Israel	1	40	1.000
	Japan	2	29	9.000
	Pakistan	1	26	130.000
	Korea Rep.	1	43	400.000
	Taiwan	3	107	1.242.000
	Tailand	1	15	10.000
Europe	Belgium	1	6	10.000
	Czech Rep.	1	10	18.000
	Finland	1	28	30.000
	France	20	259	463.200
	Germany	3	46	102.000
	Ireland	1	8	34.000
	Italy	2	43	35.000
	Netherlands	5	161	110.568
	Portugal	1	5	127.000
	Spain	2	18	115.200
	Sweden	3	96	100.000
	Switzerland	1	11	14.000
	Turkey	1	53	800.000
	England	14	174	163.432
South America	Argentina	2	48	800
	Brazil	33	835	11.590.000
	Chile	1	92	340
	Colombia	6	208	3.101.000
	Ecuador	2	108	1.143.000
	Guatemela	1	35	210
	Mexico	9	265	1.657.000
	Panama	1	9	1
	Peru	1	26	350
	Trin. and Tob.	1	25	1
	Uruguay	1	6	25
	Venezuela	2	18	60
North America	Canada	8	252	575
	United States	18	556	359
Australia	Australia	5	90	408
	New Zeland	1	6	23

Throughout the world, it is possible to see well established and succesful BRT systems such as Curitiba's BRT system. It was taken as a model system by many others because it is accepted as the oldest BRT system in the world and its success is well known by the rest of the world. The BRT line in Curitiba was opened in 1974 and extended several times till 2009. The buses operate on separated busways from the regular traffic. The fleet consists of 1930 vehicles with a capacity varying from 40 to 250 passengers for each vehicle. The BRT line in Curitiba carries approximately 2.3 Millions passengers daily. The line is 81 km with 359 stations operating on 6 corridors. A new line has been added to the BRT system called the Green Line in 2009 which services through only 100% bio-diesel articulate buses (Lewenstein and Meehan 2013).

The buses serving on different corridors are distinguished by their colors. (onlinepubs.trb.org). In Figure 2.1, a view of the tube shaped station of Curitiba's BRT line is presented. It is a station type uniqe to the Curitiba.

Figure 2.1. Tube Type Station of Curitiba's BRT Line (CTS-Brazil, Lindau *et al.*, 2011).

TransMilenio in Bogota, Columbia is one of the largest BRT systems in the world. The BRT system started to serve in December of 2000. The system is similar to the BRT system of Curitiba. The buses serve on the separated ways. The number of the buses in the fleet is up to 1600 as of October,2014. TransMilenio operates on a line of 113 km through 12 corridors and 155 stations. It carries nearly 2.2 millions passengers daily (brt.org). The color of the all buses operating in the main trunk is red. In Figure 2.2, there are two views of Bogota, one of which is before the introduction of BRT system in 1998 and the other one is after the implementation of TransMilenio.

Figure 2.2. Bogota in 1998 Before Transmilenio on Left and Bogota in 2004 After Transmilenio on Right (Hamilton and Hidalgo 2004).

TransJakarta is the BRT system of Indonesia which is the first BRT system of South Asia (Figure 2.3). The system was introduced in 2004 by the government in order to solve the problem of traffic congestion. Currently, Transjakarta is the longest one of all the BRTs in the world. It is 207 km in length with 12 corridors and 4 more corridors are planned to be added. It carries about 370,000 passengers per day (BRTdata.org). Transjakarta's fleet consists of 545 vehicles.

Figure 2.3. A view of the TransJakarta, Indonesia (Jakartapost, 2012).

2.2. BRT Implementation in Istanbul

Istanbul is a city divided into two parts by the Bosphorus, which makes the city a connection between two continents. In order to pass the Bosphorus, vehicles use either of the two bridges of the city, Fatih Sultan Mehmet Bridge and Bosphorus Bridge, to pass from one continent to the other one. The connection roads for the bridges were at first out of the city's crowded areas but in the following years people started to settle down around the connection roads, and today the bridges and the connection roads are in the center of the city, which makes the traffic problem even much bigger and harder to solve.

BRT line, namely Metrobus system, was first implemented in Istanbul in 2007. There are ongoing BRT line projects for other cities, Ankara, Kocaeli, Izmir and Bursa (Transport.com.tr).

It is located in the center of the D 100 Highway, in each direction one lane is closed for BRT line usage only. D 100 Highway lays in the middle of the cities crowded regions, and it is the route to pass the Bosphorus Bridge. It passes through Avcilar, Yenibosna, Atakoy, Bakirkoy, Topkapi, Okmeydani, Mecidiyekoy, Zincirlikuyu untill the Bosphorus Bridge. Therefore, there is traffic congestion on the D 100 Highway during both peak and off-peak hours. In Figure 2.4, a view of D 100 Highway before and after the BRT line is presented.

Figure 2.4. A view of D 100 Before Implementation of BRT Line on Left and After Implementation of BRT Line on Right in Istanbul (IETT).

The BRT line is operating in the opposite direction of the normal traffic flow of D 100 Highway to reduce the costs of constructing a station on both sides or changing the design of the buses' doors. The BRT line has its own way all through the line except at the Bosphorus Bridge.

At the beginning, the BRT line implemented only from Avcilar to Topkapi. It was deemed to be a trial phase. After the succesfull implentation of the line, which reduced the travel time from 67 minuted to only 22 minutes, new lines have been added till 2012. In Figure 2.5, the first plan of the BRT line is presented. The phases are numbered in the chronological order of their implementations.

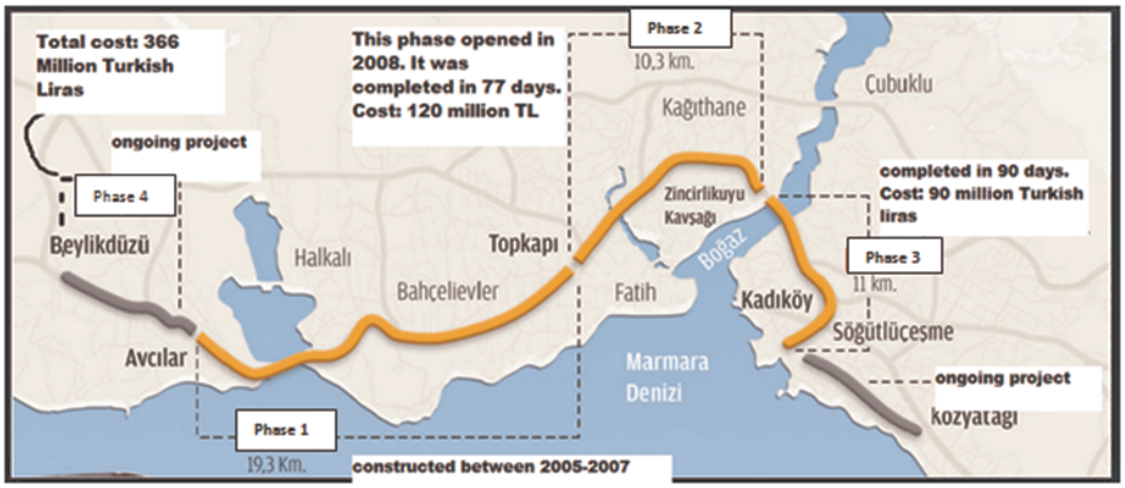

Figure 2.5. First Plan of the BRT Line (IETT).

The first phase was 19.3 km and it was completed in 8 months. It was the first BRT line of Turkey and it is followed by other phases. The second portion of the BRT line Topkapi-Zincirlikuyu phase was opened in September 8, 2008.

The second phase made the BRT line a perfect transportation alternative to reach the central business district of the city. Therefore, its success and ridership increased rapidly.

After the accomplishment of the BRT line on Europian side of Istanbul, the third line which connects the continents opened in March 3, 2009. The time of travel from Avcilar to Sogutlucesme reduced to merely 63 minutes while the same distance was taking couple of hours by private car. Eventually, the final phase, Avcilar Beylikduzu line, was opened in July 19, 2012.

After the opening of the fourth phase, the BRT line passed 50 km in length and now it has 45 stations. The period of a complete trip on the line is approximately 83 minutes. The cost of the project was planned as 366 million TL for the 3 phases. After the fourth phase, government stated its cost as approximately 466 million TL (Yazıcı *et al.*, 2013). In Figure 2.7, a detailed map of the BRT line in Istanbul is presented.

In Figure 2.6, there is a view from the BRT line in which a vehicle is leaving from the station on Avcilar-Topkapi line.

Figure 2.6. A view of BRT line, the Sirinevler Station (IETT).

Figure 2.7. Istanbul BRT Line Map 2014 (IETT).

The BRT line operates on its separated route, in the middle of the D 100 Highway. It operates in the reverse direction of the normal traffic flow, which makes people use the right hand doors of the buses from a station in the middle. The station in the middle is used since it reduces the costs and the area occupied.

The BRT line was named only as "34" at the beginning because there was only a singular line from Avcilar to Topkapi. Later, other lines have been added and ridership increased continously. Therefore, as new buses were added to the fleet of the IETT, new names were given to the new lines. The current plan and the names of the BRT lines are presented in Figure 2.8.

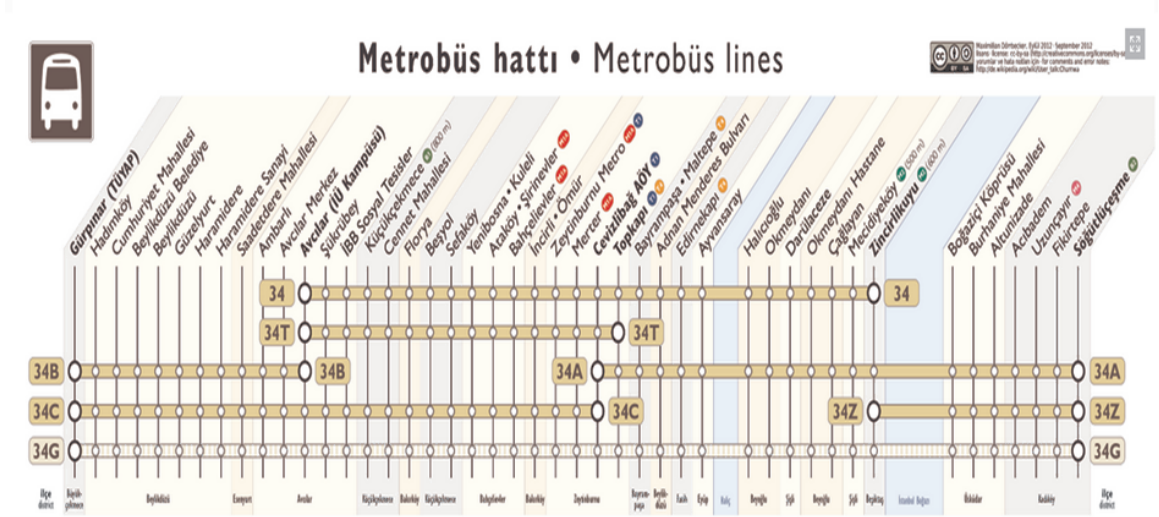

Figure 2.8. The BRT lines (IETT 2014).

There are several lines on the BRT system with different operation hours and different routes. This system is applied in order to provide a better and faster transportation facility to riders in the peak hours of the BRT line usage. In Table 2.2, the information about the BRT lines providing service on different portions of the corridor is presented.

Table 2.2. BRT line Information (IETT, 2014).

	34 Avcilar Zincirlikuyu	34A Zincirlikuyu Sögütlüçesme	34B Beylikdüzü Avcilar	34C Beylikdüzü Cevizlibag
Length (Km)	30	23	10	29
Trip Period (Min)	100	90	40	100
Number of Stations	26	19	12	26
	34T Avcilar Cevizlibag	34Z Zincirlikuyu Sögütlüçesme	34 G Beylikdüzü Sögütlüçesme	
Length (Km)	19	11.5	52	
Trip Period (Min)	60	44	180	
Number of Stations	16	8	44	

where is the 34G BEYLIKDUZU SÖGÜTLÜÇESME : Operation hours 01:30 - 05:00 (2014), is the 34T AVCILAR CEVIZLIBAG : Among the vehicles of line 34,15 vehicles serve as 34T between 15:00 and 20:40) (2014).

As new lines have been added to the first BRT line since 2007, many new buses have been added to the fleet. The current number of the BRT line fleet is 460, the distribution of the buses and features of the bus types are presented in Table 2.3 and Table 2.4.

Table 2.3. Numbers of the BRT Line Fleet (IETT, 2014).

VEHICLE TYPES	NUMBER OF VEHICLES	LOWER BASE SPEC.	FUEL TYPE
Capacity	250	yes	Diesel, Euro IV/V
Phileas	50	yes	Diesel, Euro V
Citaro	100	yes	Diesel, Euro III
Conecto	60	yes	Diesel, Euro V
TOTAL	460		

Table 2.4. Features of the Vehicle Types (IETT, 2014).

BRT line Fleet				
Vehicle	Length (meters)	Number of seats	Passenger Capacity	Number of Axles
Mercedes Citaro	18	42	150	3
Mercedes CapaCity	19.54	42	193	4
Phileas bi-articulated diesel-electric buses	26	52	230	4

The ridership during the off peak and peak hours are considered in the BRT line schedule preparation by Istanbul Public Transportation Authority (IETT). In Table 2.5, the operation hours of the buses on the BRT line are presented.

Table 2.5. Operation Hours of the BRT Line (IETT, 2014).

	34 Avcilar Zincirlikuyu	34A Zincirlikuyu Sögütlüçesme	34B Beylikdüzü Avcilar	34C Beylikdüzü Cevizlibag
Operation hours	05:00 to 02:00	05:00 to 10:00 and 16:00 to 21:00	05:00 to 02:00	05:00 to 10:00 and 16:00 to 21:00
Total (hours)	21	10	21	10
	34T Avcilar Cevizlibag	34Z Zincirlikuyu Sögütlüçesme	34G Beylikdüzü Sögütlüçesme	
Operation hours	05:00 to 10:00 and 16:00 to 21:00	05:00 to 03:00	01:00 to 05:00	
Total (hours)	10	22	4	

In Table 2.6 time intervals between buses on the BRT line is presented. The period reduces from 14 seconds to 42 seconds on the busy hours of a weekday in

order to meet the demand. The periods are different for different portions of the BRT line which is regulated by IETT according to the demand. In off peak hours of the day, average headways varying from 2 minutes to 8 minutes 34 seconds depending on whether it is weekday, Saturday or Sunday (IETT).

Table 2.6. Time Intervals Between Buses (Minutes: Seconds) (IETT).

Section of Route	Avcilar Topkapi			Edirnekapi Zincirlikuyu			Bosphorus Bridge Sögütlüçesme		
Days of week	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday
Average headway (during busiest hour)	0:14	0:24	0:36	0:17	0:24	0:40	0:42	1:05	1:15
Average headway (between 1:00 am to 6:00am)	2:00	2:51	6:00	4:17	2:51	6:00	8:34	6:40	6:40
Average headway (over 24 hours)	0:28	0:45	1:19	0:40	0:46	1:24	1:33	1:59	2:15
Number of Trips / Day	3,138	1,919	1,093	2,180	1,895	1,023	926	726	642

In Table 2.7, the number of trips made by different BRT lines is presented. The line numbered as 34 has the maximum trip because this line is operating for 21 hours through 30 stations. Therefore; in order to provide the headway period of 14 seconds in busy hours, the daily number of the trips of the line number 34 increases.

Table 2.7. Number of Trips for the BRT Lines (IETT, 2013).

		Daily Number of Trips		
Line No.	Route Termini	Weekdays	Saturdays	Sundays and Holidays
34	Avcilar - Zincirlikuyu	1.824	1.732	1.012
34T	Avcilar - Topkapi	1.284	174	70
34Z	Zincirlikuyu - Sögütlüçesme	570	566	631
34A	Edirnekapi - Sögütlüçesme	326	150	0
34G	TÜYAP - Sögütlüçesme	30	10	11
Total		4.034	2.632	1.724

Above data obtained from IETT belongs to the year of 2013. It shows the numbers of the smart card transactions. Since there is no cash accepted in any Public Transportation of the government, the data taken from the IETT is considered as

highly reliable. The payment is taken by the toll gates on the stations of the BRT line. There are totally 366 toll gates at 45 stations of the BRT line and 54 of them are for disabled people (IETT 2014). In Figure 2.9, a view of toll gates in Mecidiyekoy Station is presented. Toll gates are as seen from the Figure have wider occupation than the station to provide the flow of people entering the station and exiting from the station.

Figure 2.9. Toll Gates in Mecidiyekoy (IETT, 2014).

In Figure 2.10 the number of mean BRT line users are presented. The number of passengers for December 2013 passed 20 Millions while the number was about 12 millions in January of 2010.

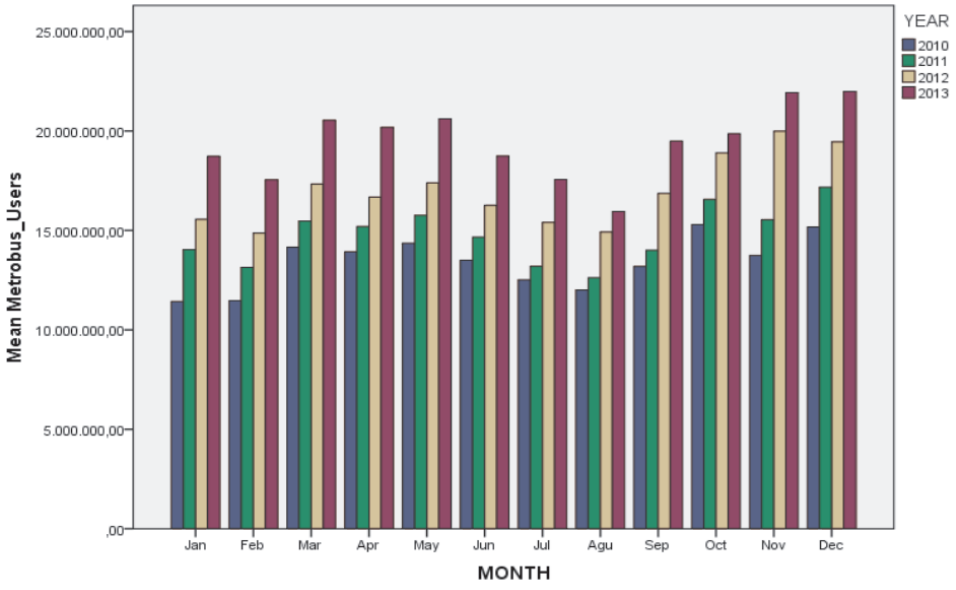

Figure 2.10. BRT Line Monthly Ridership 2010-2014 (Gökaşar, *et al.*, 2014).

The distribution of passengers are changing from one station to the other. According to the transaction data of 2013 provided by IETT, the top two stations of the BRT line are Mecidiyekoy and Zincirlikuyu stations. The total number of passengers used these two stations passed 30 millions while there was nearly no ridership in Burhaniye Station as presented in Figure 2.11.

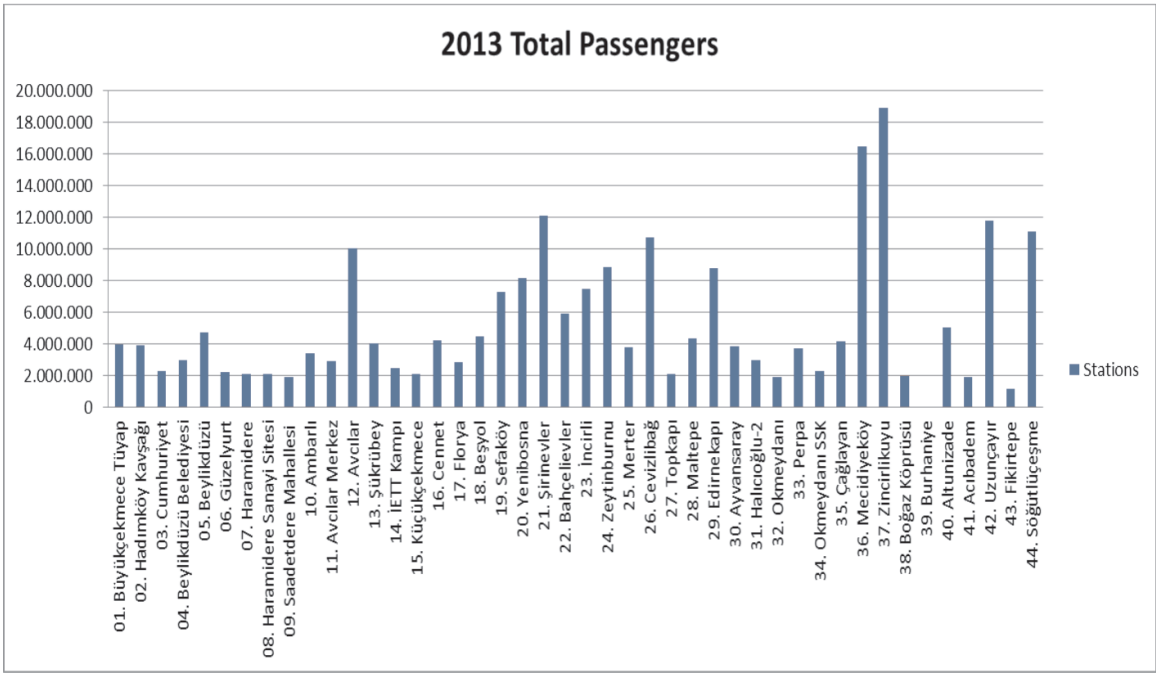

Figure 2.11. Total Passengers for Each Station of the BRT Line Line in 2013 (IETT 2014).

2.3. Previous Studies on BRT System

Easy implementation and low construction cost of BRT systems compared to other transportation modes is proved by many studies. Menckoff (2005) claimed that the busways can be developed easily as BRT lines by just closing the line only for the public transportation usage. The implementations of this process are observed in South America such as Curitiba in Brazil and TransMilenio in Bogota, Colombia.

Wright and Hook, (2007) studied the cost effectiveness of the BRT system compared to other transportation modes. According to their studies BRT has almost the same service quality and performance of rail systems with lower operational costs.

They claimed that the cost of BRT implementation is about only 5% of a LRT system implementation and approximately 1 to 10% of a Metro implementation.

Hensher and Golob (2008) compared 44 BRT systems by considering the construction costs of their infrastructures. They concluded that most of the systems cost less than 10 million dollars per kilometer. They implemented a two stage multivarite analysis to find out which parameters have significantly important for the construction costs. According to the results of their analysis intersection treatments have a statistically significant impact on construction costs.

Hensher *et al.*, (2010) made a comparison of the three forms of public transportation modes, namely light rail (LR), heavy rail (HR) and BRT, by considering the operator and user costs of each. They claimed that the BRT system is more cost effective system than the others when the running speeds are the same since BRT has lower operational costs and less waiting time with more access to the various destinations. Yet, the running speed of LR and HR systems are higher than that of BRT in average of 10 km per hour.

Other aspects of the BRT such as the cost analysis of the system were also studied. Hensher and Li (2012) investigated the factors affecting BRT patronage. They studied 46 BRT systems, opened between 1974 and 2010. They compared the systems by considering the components and features of the BRT. They identified 11 sources which have statistically significant impacts on daily number of the trips of the passengers. These sources are fare, headway, the length of the BRT network, the number of corridors, average distance between stations; whether there is: an integrated network of routes and corridors, modal integration at BRT stations, pre-board fare collection and fare verification, quality control oversight from an independent agency, at-level boarding and alighting, as well as the location of BRT.

Deng and Nelson (2013) studied the Beijing BRT Line 1. They evaluated the performance of the BRT line by considering its low implementation cost. They concluded that BRT system is a high-performance transit service which provided high quality

transportation to the people living in the regions along its route.

2.4. Previous Studies on Travel Behaviours and Attitudes Towards Public Transportation Modes and BRT

There are many studies in the literature that deals with the ridership of public transportation, the factors affecting the patronage and the attitudes. Gomez-Ibanez (1996) studied the factors affecting the ridership in Boston between 1970 and 1990. He claimed that the ridership is affected by the external factors rather than the internal factors such as pricing. He observed that the employment have more significant impact on ridership than per capita income.

In 2002, McAteer investigated the the impact of BRT service modifications on expressed attitudes toward bus ridership in Nashville, Tennessee. He conducted a survey using 399 people who are workers in Downtown area. His findings demonstrated that a separated bus way (BRT) could have significant impact on the travel behaviors of the workers. In particular, he presented some other components which have significant effect on ridership, such as "the busway; if route map and fare information were shown at every stop; if each bus displayed its route and stop information; and if each bus stop was named and that name was visible from the bus".

According to the Ridership Survey Report of the Washington Metropolitan Area Transit Authority (2005), the distance of Metro station to the living areas have important effect on the ridership. They surveyed about 2500 people to understand the effect of land use on transit ridership.

Yagi and Mohammadian (2008) investigated the willingness' of passengers to change their transportation modes to BRT in Jakarta. They surveyed 1000 respondents and concluded that the mode choices were significantly affected by "basic travel characteristics such as cost, time, and distance, and house-hold characteristics such as income and vehicle ownership, and individual characteristics such as gender/age, vehicle availability, driver' license, work/ school location, and allowance provided by

the employer".

Seyed *et al.*, (2010) studied the BRT implementation in Iran. They conducted a survey through 200 people. They analyzed the relation between the passenger satisfaction and BRT service quality by considering the variables such as driver behavior, ergonomics, bus velocities and service items. They concluded that there is a significant relationship with passenger satisfaction and BRT service quality.

Deng and Nelson (2012) studied the impact of BRT on travel behaviors and property development. They conducted a survey and observed that, implementation of BRT caused new trip generations by affecting the travel behaviors of passengers. According to their results the attractiveness of properties along the BRT corridor increased significantly after the implementation of BRT.

Tao *et al.*, (2013) researched the impact of BRT implementation on travel patterns. They studied the census data and journey-to-work travel patterns of 1996, 2001 2006 and 2011 and then modeled the relationship of BRT and travel patterns. They claimed that the location of BRT have significant impact on ridership. The distance of 800 meters is named by them as the primary catchment area. Their most important finding is that the BRT is preferred more by the commuters with access to private car.

3. PASSENGERS' TRAVEL BEHAVIOURS AND ATTITUDES TOWARDS THE BRT LINE

3.1. Methodology

Main purpose of a public transport system is to serve people; hence, the satisfaction level of the passengers should be a critical determinant for the evaluation of the system. In order to be preferred by an increasing number of people, the system should always be renewed and the quality of its services should be raised. A survey is conducted throughout the BRT line to analyze the travel behaviors of passengers and to learn their attitudes towards the BRT line.

3.1.1. Design of the Survey

The most common types of field questionnaire surveys are Revealed Preference (RP) surveys and Stated Preference (SP) surveys. "Traditionally, analysis of preference and behavior were based on the Revealed Preference (RP) method, in which the observation was made on the existing transportation system (actual market)" (Sivakumar, Okamura, Yabe, Nakamura, 2006). SP surveys refer to asking consumers about their preferences, choices, frequencies of use, and so on, while revealed RPs refer to actual choices (Louviere and Street, 2000).

A survey is designed to investigate the riders' travel behaviors and attitudes towards the BRT services. The survey questions are categorized into four groups, each having different purposes. First group is regarding the demographic information of the respondents. The second group seeks to evaluate the travel characteristics of the respondents. The third group aims to analyze the attitudes of the respondents towards BRT line. The fourth group of the survey questions is used to analyze the primary reasons of the respondents for preferring the BRT line and the overall satisfaction levels of the respondents. In Table 3.1, the questions and the answer set of the first part of

the survey is presented.

The first part of the survey consists of 5 demographic information questions (Table 3.1). They are categorizing the gender, age, education level, car ownership and monthly income of the respondents. The income levels are designed by considering parameters such as the subsistence wage and the poverty line announced by the government in 2014 (turkis.org.tr , 2014).

Table 3.1. First Part of the Survey 1.

Questions of the Survey about BRT line						
Ques. 1	Gender	Male	Female			
	1	2				
Ques. 2	Age	0-18	18-35	35-50	50-65	65+
		1	2	3	4	5
Ques. 3	Education Level	illiterate	primary school	high school	college	graudate
		1	2	3	4	5
Ques. 4	Do you own a car?	Yes	No			
		1	2			
Ques. 5	Monthly income (TL)	0-750	750-1500	1500-2500	2500-5000	5000+
		1	2	3	4	5

The second part of the survey also includes five questions. These questions aims to obtain attitudes towards the BRT line ridership. In this part, how often people are using BRT line (Question 6), does BRT line close the where they live and where they travel (Questions 7 and 8), with what purpose they use BRT line (Question 9) and how far they travel with BRT line (Question 10) questions are asked (Table 3.2).

Third part of the survey is the main part because answers to the survey questions reflects the condition of the BRT line from riders' perspective. There are 3 questions as shown in Table 3.3, which aims to determine the riders' satisfaction levels.

Table 3.2. Second Part of the Survey 2.

Questions of the Survey about BRT line						
Ques. 6	How often do you use BRT line ?	several times in a year	several times in a month	several times in a week	once in a day	several times in a day
		1	2	3	4	5
Ques. 7	How many transfers did you make until the BRT line ?	0	1	2	3	4+
		1	2	3	4	5
Ques. 8	How many transfer will you make after using the BRT line ?	0	1	2	3	4+
		1	2	3	4	5
Ques. 9	What is your travel purpose ?	work 1	education 2	shopping 3	visit 4	others 5
Ques. 10	How many stations will you travel?	3-Jan	9-Mar	18-Sep	18-30	30+
		1	2	3	4	5

Table 3.3. Third Part of the Survey 3.

Questions of the Survey about BRT line						
Ques. 11	Do you think the BRT line integration points and overpass capacities are sufficient?	very insufficient	Slightly insufficient	Sufficient	Sufficient Slightly	very sufficient
		1	2	3	4	5
Ques. 12	Do you think the BRT line vehicle capacities are sufficient?	Very insufficient	Slightly insufficient	Sufficient	Sufficient Slightly	very sufficient
		1	2	3	4	5
Ques. 13	Do you think the BRT line station capacities are sufficient?	very insufficient	Slightly insufficient	Sufficient	Sufficient Slightly	very sufficient
		1	2	3	4	5

In Table 3.4, the final part of the survey is presented. The first question is about the main reasons of passangers to prefer BRT line instead of other public transportation alternatives. The second question is about the evaluation of passengers overall satisfaction levels. The last question is asking riders thow much they support a future metro project on BRT line.

Table 3.4. Fourth Part of the Survey 4.

Questions of the Survey about BRT line						
Ques. 14	Why do you prefer BRT line? (In importance order)	Fast	Safe	Cheap	No alternative	Others
		1	2	3	4	5
Ques. 15	Are you pleased with the BRT line?	Not pleased	Slightly pleased	pleased	Strongly pleased	Totally pleased
		1	2	3	4	5
Ques. 16	How much do you support a future metro project on BRT line?	Not agreed	Slightly agreed	agreed	Strongly agreed	Totally agreed
		1	2	3	4	5

3.1.2. Sampling Procedure

Although it is necessary to represent the whole population of the city which is currently 15 millions (TUIK, 2014), convenience sampling is utilized. Convenience sampling is a method which performed when the number of the population, hence, the probability of being selected for the samples is unknown. The samples are selected from the locations where they are convenient. Therefore, the probability of being selected is higher for convenient samples. However, convenience sampling can cause bias problem (Ozdemir *et al.*, 2011). In order to mitigate the bias problem, some studies using these methods support their findings mostly by the reports of the government and previous studies (Denstadli, 2011). An alternative method for decreasing this bias is to take samples from outside the convenient population (Richardson, Ampt, and Meyburg 1995).

Therefore, the survey is conducted also in various locations of the city, which are not on the BRT line corridor. The group of respondents selected from outside the BRT line corridor is named as the outer respondents. Total number of respondents is 252, 73 of which is the number of respondents in the outer group. The analysis is performed for both the overall respondents and the outer respondents.

3.1.2.1. Time Period of the Data Collection. Alpkokin and Ergün (2012) provided ridership of the BRT line in Istanbul for one weekday. The number of passengers are changing throughout the day (Figure 3.1). In this study, the survey time interval covers random hours of a day, including peak and off peak hours on weekdays and weekends between 20th of September 2014 and 20th of November 2014.

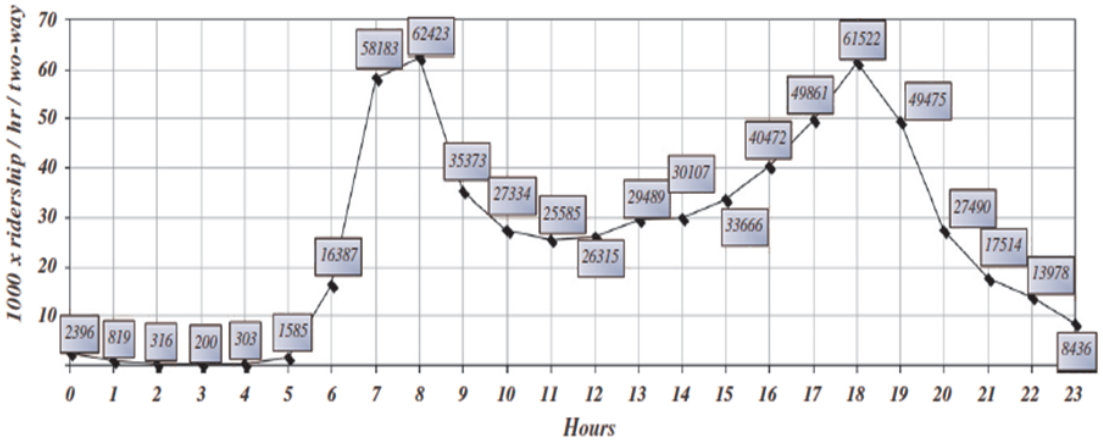

Figure 3.1. BRT line Ridership in a Weekday, BRT line (Alpkokin and Ergün, 2012).

3.1.2.2. Location of the Survey and Selection of Passengers. The survey covered all the BRT line (53 km) by randomly selecting riders on each station and in all the bus lines' vehicles (Figure 3.2).

Figure 3.2. BRT Lines (IETT 2014).

The survey is also conducted in various districts of the Istanbul which are not on the BRT line corridor's catchment area. The cathchment area is defined by Tao *et al.*,

(2013) as the area inside 800 meters to the BRT line. The districts in which the survey is performed are namely, Arnavutkoy, Eyup, Sariyer, Basaksehir, Beykoz, Cekmekoy, Kartal, Sultangazi, Bayrampasa. The districts of Istanbul, are presented in Figure 3.3.

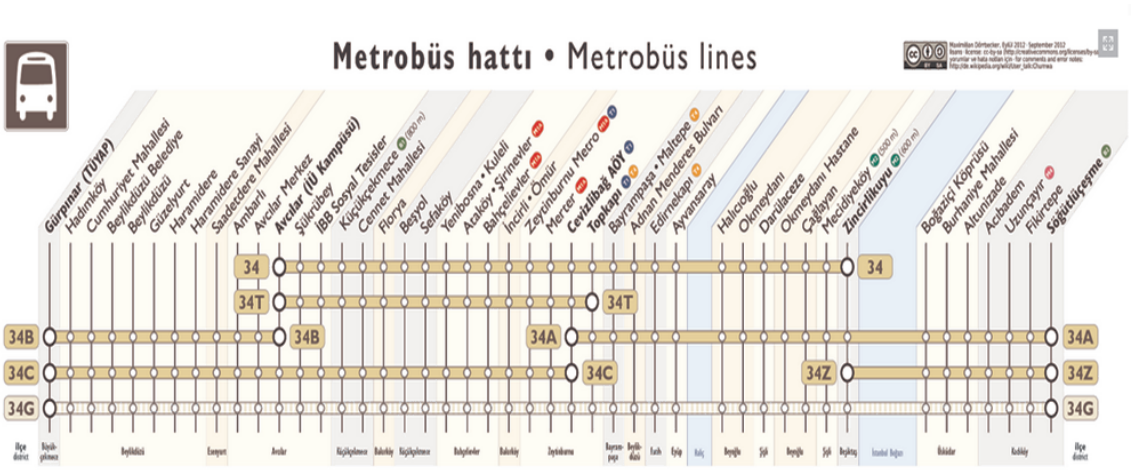

Figure 3.3. BRT Lines (IETT 2014).

Convenience sampling method is used in this study. Then, to reduce bias in the sampling process problem, the respondents are selected from the BRT line and outside of its catchment area randomly. When conducting the survey, first the purpose of the survey is explained to the respondents and then they were left alone to answer the questions.

The data is collected from 252 respondents, 73 of which are selected from outside of the BRT line cathcment area. The total response was about 280 yet some of them were either answered partially or not answered properly. The efficiency of the survey was 90%. In the following, the data analysis, consisting of two sections, is performed. The first part is the presentation of statistical data of the respondents using graphical methods. The second part includes the evaluation of the SPSS analysis results.

3.1.2.3. Demographic Data of the Respondents. In the survey, total number of the respondents is 252. Almost an equal portion of man (51%) and women (49%) is interviewed. The outer group consists of 73 respondents, 53% of which is female.

Figure 3.4 shows that the age distribution of the respondents. The number of the respondents in the age interval 18-35 are larger than the other age intervals for both total and outer groups.

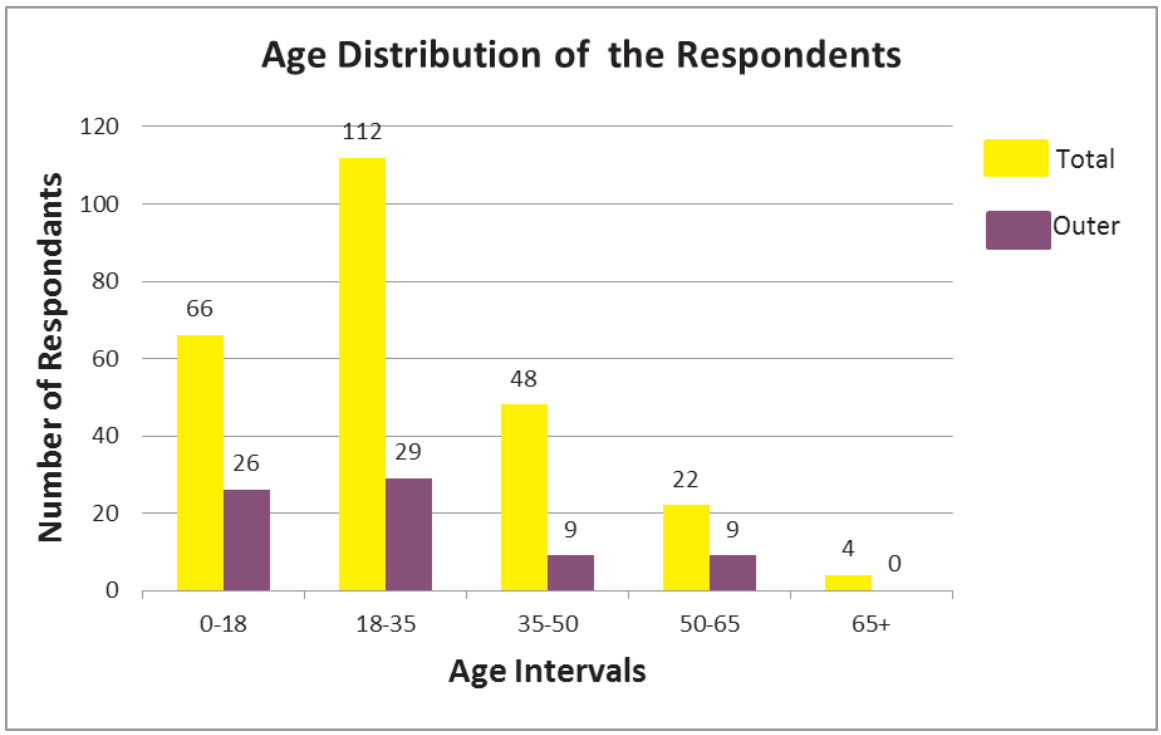

Figure 3.4. Age Distribution of the Respondents.

Figure 3.5 shows that the majority of the respondents have high school education, which is followed by college and primary scool education groups.

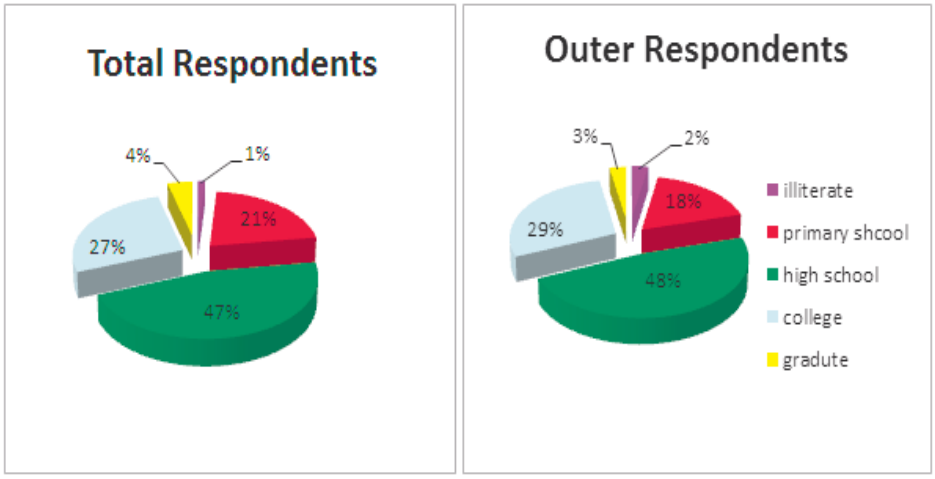

Figure 3.5. Education Levels of the Respondents.

The factors affecting the travel behaviors and attitudes towards public transportation modes have been studied previously in the literature. Auto ownership is indicated as one of the most important factors by many researchers such as Freund and Martin, 1997, Acker and Witlox, 2010, Murray *et al.*, 2010. Hence, one of the critical conditions for the analysis is the auto ownership. The respondents were asked if they own a car or not. The majority of the respondents do not have a car, yet the ratio of the car owners in both total and outer group is also high. Almost equal number of percentages namely, 70% and 71% of the total respondents in the total and outer group respectively, do not own a car.

Figure 3.6 demonstrates the monthly income levels of the respondents. According to the survey data, the respondents in the low (0-750TL) and mid low (750TL-1500TL) income levels creates the 57% of the total respondents and 63% of the outer respondents.

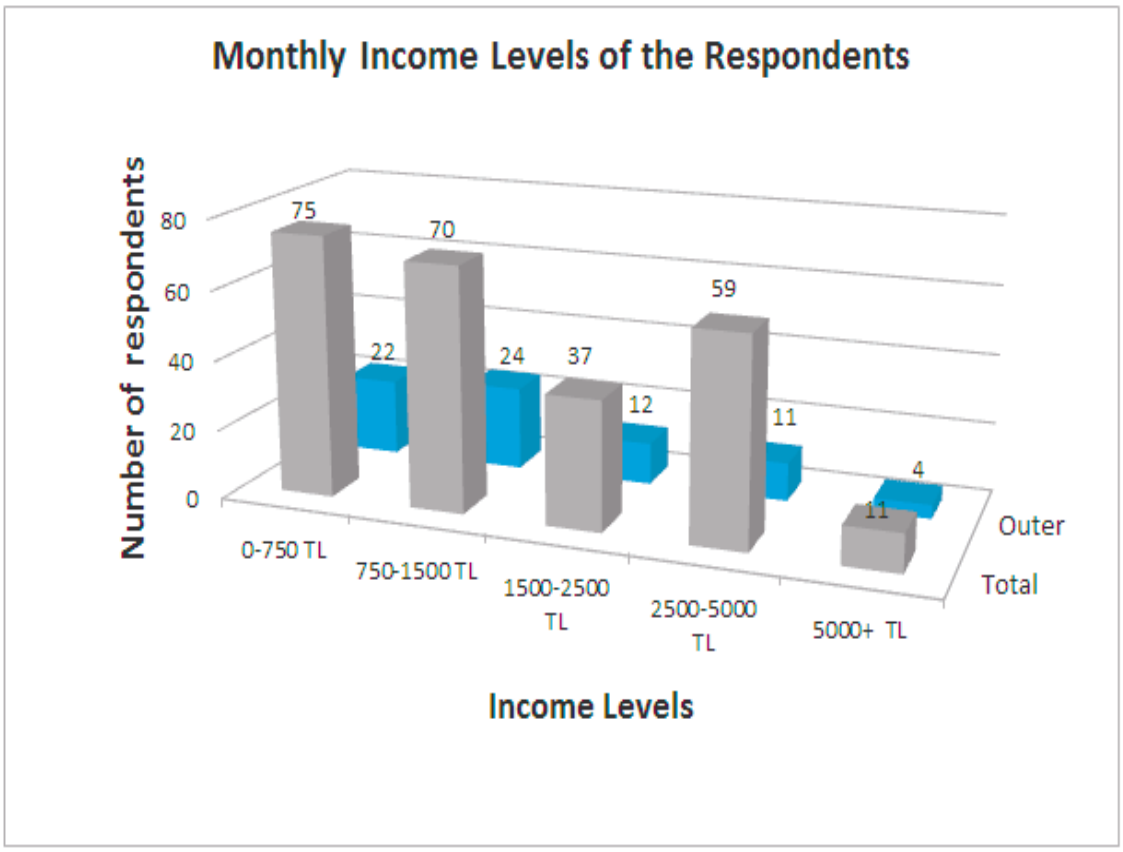

Figure 3.6. Distribution of the Monthly Income Levels of the Respondents.

The data collected also provides information about the travel characteristics which will be used for the statisical analysis in the following section.

As seen in Figure 3.7 below, 56% of the total respondents and 51% of the outer respondents prefer the BRT line because of its speed. The riders who prefer it for being an economic type of transportation is 2.7% of the total respondents and 1.3% of the outer respondents. The number of "having no alternative" group is also high because for some destinations of the BRT line, people have to use two or more different transportations if they do not use the BRT line.

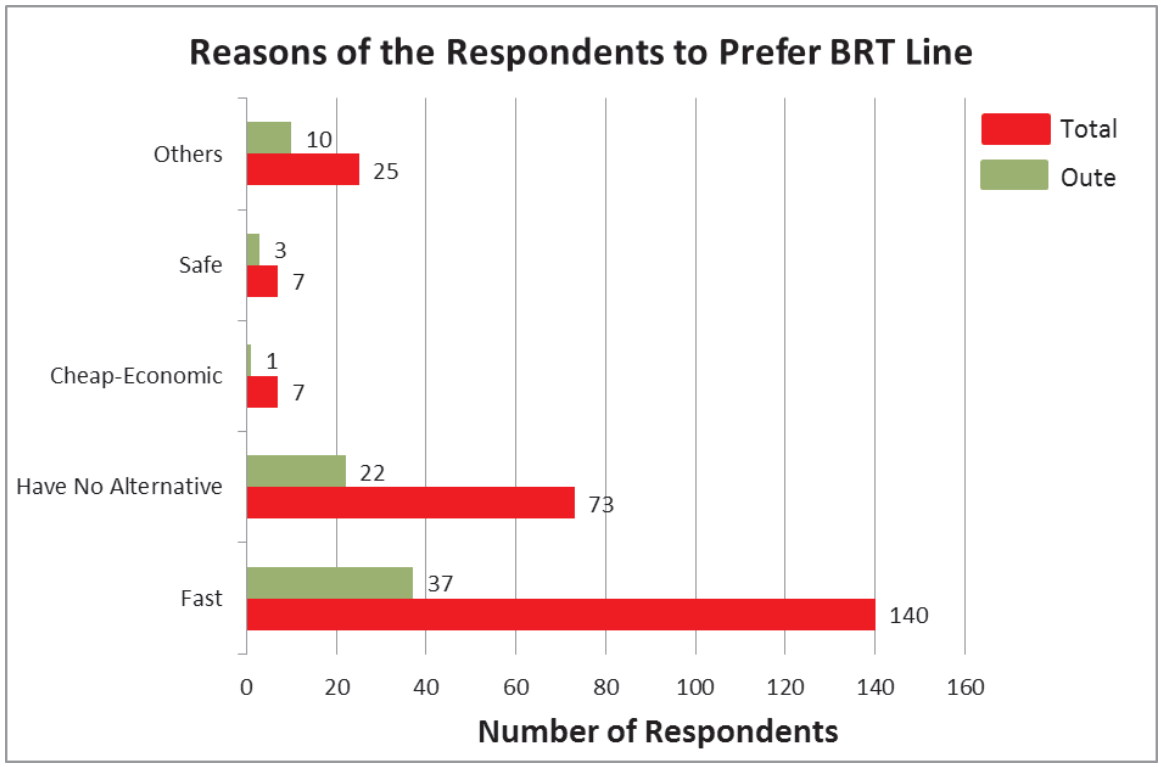

Figure 3.7. Distribution of the Reasons of the Respondents to Prefer BRT Line.

Figure 3.8 shows that 28% of the total respondents uses the BRT line in order to go to work while 31% of the outer respondents is sharing the same purpose. 24% of the total respondents use the BRT line for "other" purposes. This ratio is 12% for the outer respondents. This might be due to the fact that along the BRT line there are many residential areas, amusement parks, shopping malls and so on. Therefore, the respondents might have various travel purposes which cannot be put into same

categories.

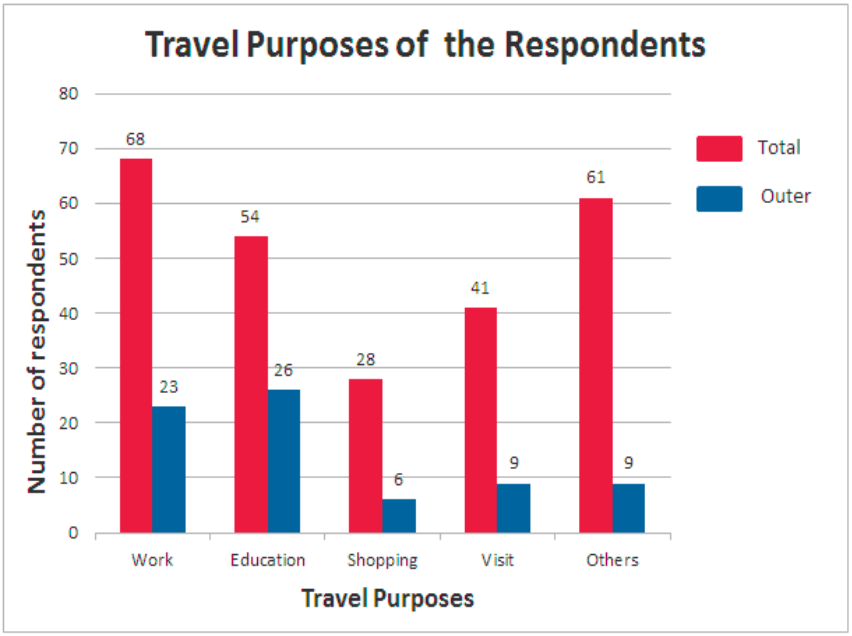

Figure 3.8. Distribution of the Travel Purposes of the Respondents.

The number of the stations that each respondent would be travelling is also asked. As presented in Figure 3.9, 35% of the total respondents and 28% of the outer the respondents traveled through 9 and 18 stations. 34% of the total respondents and 36% of the outer respondents travelled between 3 and 9 stations. The ratio of the respondents travelling through more than 30 stations is 2% and 1% for the total and outer respondents, respectively.

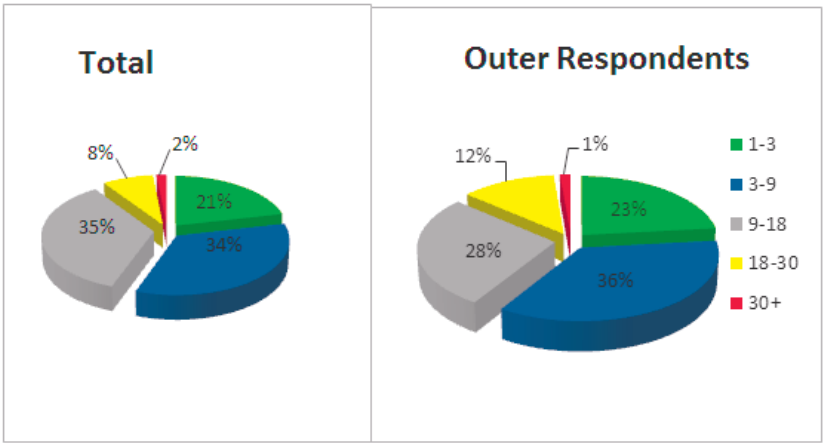

Figure 3.9. The Number of the Stations which has Been Traveled by the Respondent.

3.2. Results of the Analysis

3.2.1. Statistical Analysis of the Travel Behaviors and Attitudes of the Respondents Towards the BRT Line

This part of the analysis have four subsections each investigating a different aspects of the travel behaviors and attitudes of the riders using one-way ANOVA and independent samples t-tests in SPSS.
The assumptions for the ANOVA test are as follows:

- Each sample is an independent random sample.
- There are two or more categorical groups. The carownerhip data has has 2 independent groups; therefore, independent t-test is performed.
- The distribution of the response variables follows an approximately normal distribution.
- The population variances are equal across responses for the group levels which is called also homogeneity of variances. Equal variances are also assumed for independent t-tests in this study. (Lee *et al.*, 2005).

In Table 3.5, the first row contains the answers to the question 11 where the second row is the answers to the question 12, the part "Capacity of the stations on the BRT line" contains answers to the question 13 and tha part "Overall satisfaction level" contains answers to the question 15.

As shown in Table 3.5, there is no statistically significant effect of travel frequency on the attitudes of riders towards the BRT line. The results are similar for both the outer respondents and total respondents. According to survey results, the riders rated their overall satisfaction level as 2.89 points over 5.00, which proves that there is still room to increase the overall satisfaction level of riders. Beira and Cabral (2007) suggested that "in order to increase public transport usage, the service should be designed in a way that accommodates the levels of service required by customers and by doing so, attract potential users".

Respondents are divided into 5 groups depending on their travel purposes, all of which are work, education, shopping, visit and others.

Table 3.5. P Values for the Travel Frequency, Travel Purpose and Auto Ownership Factors.

	Travel Frequency		Travel Purpose		Car Ownership	
Attitudes towards BRT	p- values		p- values		p- values	
	TOTAL	OUTER	TOTAL	OUTER	TOTAL	OUTER
Capacity of the pedestrian overpass sections and integration modes	0.365	0.693	0.011*	0.3	0.913	0.45
Capacity of the vehicles on the BRT line	0.234	0.094	0.000*	0.039*	0.002*	0.008*
Capacity of the stations on the BRT line	0.099	0.426	0.003*	0.26	0.403	0.701
Overall satisfaction level	0.198	0.114	0.352	0.235	0.522	0.402

where is the $*$ Means significance level < 0.05.

The results showed that there is a capacity perception difference between the respondents with shopping purposes and the rest of the respondents. This difference has statistically significant importance. According to the survey the respondents travelling with shopping purpose rated the station and vehicle capacities of the BRT line as insufficient. They are the most dissatisfied group compared to the other groups. The riders who travel for shopping also have lower overall satisfaction level. That might be a result of the fact that riders who are carrying shopping bags experience serious troubles while getting on the BRT line vehicles. Since there is not enough room even for passengers in the BRT line vehicles during peak hours. Even if they get on the BRT line without any trouble, long distances with heavy bags in the crowd can be really challenging.

Another approach is also possible that the passengers travelling with shopping purposes have lower tolerance for capacity problem due to the fact that they do not have any obligations to travel as the commuters with work and education purposes.

Those might be the reason why the satisfaction level of the respondents who aim to go for shopping by the BRT line is lower compared to other groups. It is probably possible to generalize this result especially for entire population especially for vehicle capacities because total group and outer group have similar attitudes.

In the first part the answer to the question whether owning a car or not is considered as a yes or no type. Hence, an independent sample t-test is conducted for the analysis. The respondents' ideas regarding the capacity of the BRT line overpass and integration modes, and the capacity of the BRT vehicles and stations are asked in the question 11 and 12, 13 respectively. The question 15 is asked to evaluate the BRT line overall satisfaction level of respondents (Table 3.9).

Table 3.6. Group Statistics for the Car Ownership and Questions 11,12,13 and 15.

Group Statistics					
	Car ownership	N	Mean	Std. Deviation	Std. Error Mean
q11*	yes	76	2.08	1.421	0.163
	no	176	2.16	1.405	0.106
q12*	yes	76	1.86	1.458	0.167
	no	176	1.4	0.808	0.061
q13*	yes	76	2.45	1.389	0.159
	no	176	2.62	1.537	0.116
q15*	yes	76	2.62	1.583	0.182
	no	176	2.49	1.426	0.108

where is the $*$ q11 refers to the 11th question, is the $*$ q12 refers to the 12th question, is the $*$ q13 refers to the 13th question, is the $*$ q15 refers to the 15th question.

The results presented in Table 3.7 shows that according to the respondents who do not have access to a private car rated the vehicle capacity of the BRT line as insufficient compared to the respondents who own one. This result is valid for both the total and outer group. This is due to the fact that the passengers who have access to the comfort and space provided by the private car might have lower tolerance to the crowd. According to Alpkokin and Ergün (2012), the BRT line is carrying over 20.000 passengers per hour through 16 hours of a day.

Table 3.7. Group Statistics for the Car Ownership and Question 6.

Group Statistics					
	Car ownership	N	Mean	Std. Deviation	Std. Error Mean
q6	Yes	76	3.91	1.122	0.129
	No	176	3.34	1.363	0.103

where is the $*$ q6 refers to the 6th question.

The results presented in Table 3.10 demonstrates that for the total group there is a significant difference between the travel behaviors of the respondents and different income levels. However, for the outer group, income level does not have statistically significant impact on the travel frequency. That is a probable reason of why people who are not close to the BRT line do not use it frequently whether they are in low income or high income group.

Table 3.8. Comparison of the Riders' Travel Behaviours for Monthly Income Levels and Car Ownership.

	Monthly income		Car Ownership	
Riders' Travel Behaviours	p- value		p - values	
	TOTAL	OUTER	TOTAL	OUTER
Travel Frequencies	0.038*	0.124	0.001*	0.162

where is the $*$ Means significance level < 0.05.

The results also indicate that for the total group there is a significant difference between the respondents who have access to a private car and do not have access to a private car. For the outer group car ownership does not significally affect the travel frequencies. For the total group, the mean of the respondents who have access to private car is 3.91 where the mean of the respondents who do not have access to the private car is 3.34 . This result might be the reason of the heavy congestion of the traffic on D100 Highway* during peak and off peak hours of the day.
D 100 Highway is the highway on which the main corridor of the BRT line lays.

3.2.1.1. The Effect of the Ease of Access on the BRT Line on Travel Behaviors. According to the results presented in Table 3.10, there is an impact of the ease of access on the BRT line on travel frequency for the total group and this impact is statistically important. Yet, there is no significant impact of the ease of access on the BRT line on travel frequency for the outer respondents.

Table 3.9. The Affect of Ease of Access to the BRT Line on Travel Behaviors.

	Ease of access to the BRT line	
Travel Behaviors	p- values	
	TOTAL	OUTER
Travel Frequency	0.015*	0.951
Means significance level ¡ 0.05		

- Means significance level < 0.05.

3.2.1.2. The Impact of the Socio-Economic Characteristics of the Respondents. The increasing population of Istanbul, urging the authorities to plan new projects to provide with the expectations of the society. Similarly, the number of the BRT line ridership is increasing very rapidly thereby causing capacity problems and low satisfaction levels. Some of the previous studies (Hidalgo, 2005, Hensher *et al.*, 2010) suggest railway systems when the BRT is not sufficient to meet the demand. Yet the cost of the project, and its solidity for the regulations and changes make it a challenging issue (Hensher *et*

al., 2010). There are various suggestions of metro project along the BRT line (IUAP, 2012). In the survey, the respondents were asked how much they support a metro project instead of the BRT line. Then, the results were analyzed for socio-economic characteristics of the respondents.

The analysis presented in Table 3.10, showed that there is no significant difference between the education levels for both total and outer groups on supporting the future projects. The mean of all the groups is 3.59/5.00. This average value shows that the respondents from any education level are likely to welcome new projects on the BRT line.

Table 3.10. Comparison of the Riders' Attitudes Towards the Future Projects on BRT for Education Level.

Riders' attitudes towards the Future Projects on BRT	Education Level		Monthly income	
	p- value		p- value	
	TOTAL	OUTER	TOTAL	OUTER
Ideas about the Metro Project	0.18	0.934	0.179	0.934

These results also suggest that the future projects along the BRT line are also found beneficial by the respondents with any level of income. Outer group and total group showed the same tendency against the future projects. These results also supported by the investigation of the government in 2013 about the satisfaction of passengers about the public transportation in Istanbul (IETT, 2013, Passenger Satisfaction Survey).

4. CONCLUSIONS AND RECOMMENDATIONS

The BRT line in Istanbul helped authorities minimizing travel time in the existence of increasing traffic congestion on D100 Highway. However, the system should renew itself and improve the service quality due to the fact that the overall satisfaction level of the riders is one of the critical determinants of the number of the ridership.

In this study, a questionnaire is conducted to evaluate the travel behaviors and attitudes of the riders towards the BRT line in Istanbul.

According to analysis results, the respondents who prefer the BRT line because they have no alternative are 29% of the total respondents and 30% of the outer respondents. Most of the respondents do not think that BRT line is a cost efficient way of transportation for passengers. Only 3% of the total respondents and 1.3% of the outer respondents prefer BRT line because it is an economical way of transportation. 25% of the total respondents use BRT line when they travel for work which is 31% for the outer group. 35% of the total respondents use BRT line to travel for 9 to 18 stations, which is followed by 3 to 9 stations (34%).

The percentage of the respondents who own a car is a high value for both total (30%) and outer groups (29%). One might conclude that the BRT line is making people to use public transportation instead of private cars due to some factors that are not analyzed in this study. One of the factors, however, may be the fact that the BRT line is lying on the D 100 Highway, where there is almost always heavy congestion in peak hours and off peak hours of the day.

The respondents evaluated the vehicle capacity of BRT line as 1.3/5.00. Authorities have been working on some projects to solve the capacity problem. One of the most stated suggestions is establishing Metro network also covering our study area (IUAP, 2011).

The location of the BRT line might also affect riders' preferences (Tao *et al.*, 2013). The outcome of this study also showed that the travel frequencies of the respondents increase when the distance between the BRT line and the living area of the respondents decreases. 40% of the total respondents reach the BRT line without any transfers where 53% use one transfer, 7% use two transfers and none of the respondents use three or more transfers. One possible solution to decrease this adverse effect of the above stated distance on the number of ridership is that the BRT line could be provided with additional lines covering most of the city. This will eventually increase the catchment area (Tao *et al.*, 2013).

Statistical analysis showed that monthly income levels of the respondents have significant effect on their travel behavior. 30% of the total respondents preferring the BRT line is in low income group (0-750TL) and the ratio is 28% for the mid low income group (750-1500TL). However, the respondents preferring the BRT line with an income level over 5000TL is only about 5% of the total group. Yet, it is still possible to attract these people by offering them better experiences and increasing the service quality of the BRT line.

Mainly most of the respondents rated the capacity of the BRT line, in terms of available number of vehicles, stations and integration parts, as insufficient. In order to provide a separated busway to the BRT line, three of the active lanes on the D 100 Highway is closed, causing more traffic congestion on the Highway. Therefore, people prefer the BRT line for its speed rather than its service quality.

There are some ongoing research on the BRT line stations. For example, TUBITAK and IETT signed a protocal regarding capacity increase of the BRT line (IETT 2014). The project is planning ro reschedule the operation hours of the BRT line by considering the peak hours and off peak hours. The number of integration points from the BRT line to other transportation modes is also planing to be increased.

Finally, nearly all of the respondents are looking forward to see new projects from the authorities. In the Millenium and space era, it can be seen acceptable that people

have higher expectations from the facilities provided for the public use, especially in the most crowded city of Turkey. This study is providing the researchers understanding of the contidions of public services from the public perspective. The findings of this study have important implications for future BRT expansion in Istanbul or Metro line over the BRT line. This study is a guide describing the effects of BRT line on travel behaviors of passengers in an Istanbul metropolitan context.

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