Integration of Carsharing with Rail Transit for Airport Ground Access: A case of Istanbul Sabiha Gökçen International Airport (SAW)

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Abstract

With the growing population and consequently traffic problems, mobility in urban areas has become a serious issue. This also exists for the connection between the city centers and airports. Istanbul, with an approximate population of 15 million, is no exception. Currently, the city is not directly connected to Istanbul Sabiha Gokcen International Airport (SAW) by rail. Descriptive data and a binary logit model developed from a questionnaire obtained in SAW is used to understand the mode choices of passengers for egressing from SAW. Results demonstrate that there is a passenger profile who does not want to compromise on his/her travel comfort. This decision is independent from their trip purpose and their distance from the subway stations. Hence, to enhance mobility and sustainability in transportation, a carsharing service, which is targeting these passengers, between SAW and Tavsantepe station of Kadikoy-Tavsantepe semi-rapid transit line, is proposed. This will bring two advantages for these passengers. First, they will pay a lower fare compared to taxi; and second, they will experience a more comfortable trip than they would on public buses. By this way, it is aimed that passengers will avoid taxis and private cars from SAW, use the carsharing vehicles to Tavsantepe station, and continue to their destinations in Istanbul with rail transit. Thus, the sharing economy is expected to reduce the number of vehicles in the city's congested areas and increase the share of public transit modes for the trips between SAW and the city.

Keywords: *Airport egress, binary logit, carsharing, mode choice.*

1 Introduction and Background

Air travel is becoming more and more important by the day and due to this fact, the airports of cities are also gaining significant importance. Istanbul with a population of 15.2 million people (TUIK - Turkish Statistical Institute, 2016) has two airports that are operating and a third airport is currently under construction. Istanbul Sabiha Gökçen International Airport (SAW) served 31.3 million passengers (Sabiha Gökçen International Airport, 2018) whereas Istanbul Atatürk International Airport (IST) served 63.7 million passengers in 2017 (TAV Airports, 2018). The fact that Istanbul being one of the cities that suffer from traffic congestion the most around the globe (TOMTOM, 2017) combined with these high amounts of demand for both airports of the city, makes the public transportation mode much more important for the increased accessibility of the airports.

A passenger who wants to arrive at or leave from SAW can use a private vehicle, taxi, public bus or the private shuttle service of the Airport, called "*Havabus*". For a passenger who wants to go to IST has the same options as well as a subway option. The subway line, namely Kadikoy-Tavsantepe metro line, is currently under construction for expansion to SAW. The importance of a subway system for a city with a large population and high traffic congestion levels like Istanbul is crucial. Public transportation systems such as subways are critical for reduction of the total number of vehicles in road network. Hence, to maximize their efficiency, they should be constructed in places such that the transit area of influence over a city must be maximized for the benefit of the passengers.

There are three types of spatial areas covered by this transit area of influence standard which are called; core station area, primary catchment area and secondary catchment area (APTA Standards Development Urban Design Working Group, 2009). These categories are ordered from the most significant influencer of the mode selection of a passenger to the lesser. These areas are significant factors for selecting a public transit mode. However, the characteristics of the airport passengers also have a significant impact on their choice of mode of transportation for reaching and leaving the airport.

On making a transportation mode choice for trips to and from airports, their age, income, travel purpose, length, duration and cost of the trip are determined as significant factors in a previous study (Choo et al., 2013). Factors such as the size of the groups for passengers travelling in groups (Akar, 2013; Tam et al., 2008) and the number of luggage they are carrying (Akar, 2013; Budd et al., 2014; Harvey, 1986) are deterring factors for passengers from using public transportation to access to or egress from airports. These factors are not always valid for all types of passengers. While age and income level factors are significant for non-business passengers, they have no effect on the decision making process of business trip making passengers (Harvey, 1986). There is also a category of passengers whom do not want to sacrifice their level of comfort, no matter what the alternative modes offer, and have a very large resistance for giving up their decision of using private vehicles for trips between the city and airports (Budd et al., 2014). For these passengers, car-sharing is a good solution to satisfy their demand with a level of comfort and privacy which they can also have in their private vehicles.

Car-sharing is one of the most impactful mode of transportation which can significantly decrease the number of vehicles in traffic. Thus, a reduction in congestion level and travel time can be obtained. Providing incentives such as reduced parking costs and public transportation fares for combining car-sharing with public transportation will maximize the efficiency and promotion of these systems which are both crucial for reducing the number of vehicles and vehicle ownership in the city (Cervero & Tsai, 2004; Giesel & Nobis, 2016).

In this study, a car-sharing system between SAW and the Park and Ride location at Tavsantepe station of Kadikoy-Tavsantepe subway line is proposed. It is aimed to support this by showing the current tendency of arriving passengers for comfortable travel modes such as automobile and taxi in favor of public transit by descriptives and binary logit choice model. It is also aimed to deter these passengers from using these modes by providing a comfortable mode such as car-sharing until the nearest public transit station to SAW, Tavsantepe, so that they will take the public transit from this station.

2 Proposed Service and Descriptive Data

2.1 Proposed Service

In this research, a carsharing service between the Park and Ride (P&R) location of ISPARK at Tavsantepe and SAW is proposed. Thus, passengers will have a mean of transportation cheaper than but as comfortable as taxi between the subway station at Tavsantepe and SAW. Figure 1 shows the locations of the P&R facility and SAW. At SAW, the carsharing vehicles could be located at a designated area inside the car park area of SAW.

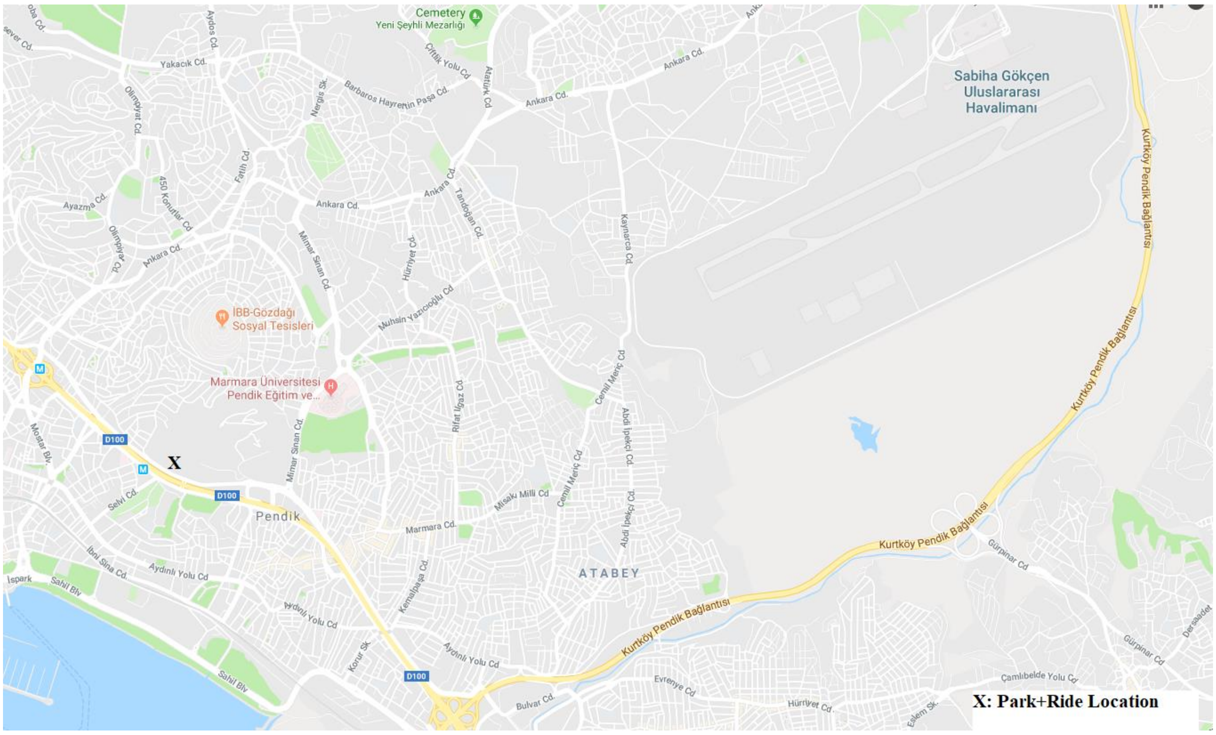

Figure 1. Map of SAW and the P&R facility of ISPARK.

There are several routes between the P&R and SAW. However, for cost calculations, it is assumed that taxis and passengers take the fastest route (15 km), which is the highway between SAW and D-100 adjacent to P&R. It takes 14 minutes to travel. The taxi rate in Istanbul is given in Eq. (1).

$$R = 4.00 + 2.50 * D + 0.385 * T \qquad (1)$$

, where *D* is the distance traveled in km and *T* is the travel time in minutes.

According to Eq.1, the cost between SAW and P&R is 47 TL. However, the carsharing rate is cheaper than this fare. For this service, only the fare per distance will be paid, which is 0.55 TL/km. Thus, the total cost for the carsharing service is 8.25 TL. Hence, it is aimed to provide a switch to the public transit station at Tavsantepe from automobile and taxi usage to the destinations in Istanbul.

2.2 Descriptive Data

The data collected at SAW by convenience sampling also supports our proposal. Table 1 shows the distribution of the modes used for the travel from SAW to Istanbul. It can be seen that 51.6 % of the passengers used automobile and taxi; namely the more comfortable modes.

Table 1. Mode shares.

	Frequency	Percent (%)
Automobile	99	40.9
Public Transit	63	26.0
Shuttle	54	22.3
Taxi	26	10.7
Total	242	100.0

The proposed idea of carsharing is evaluated by analyzing the descriptive statistics of the data and developing a binary logit model for their mode choices. Literature indicates that demographics of the passengers influence airport access and egress mode choices. Table 2 shows the demographics of the passengers below. It can be observed that most of the passengers in the data were male, university graduates, did not own automobiles, were travelling for vacation purposes and their trip costs were mostly paid by themselves.

Table 2. Demographics of the passengers in the data.

		Frequency	Percent
Gender	Male	140	58
	Female	102	42
	Total	242	100
Education	Primary School	7	3
	High School	41	17
	Undergraduate	151	62
	Graduate	34	14
	Ph.D.	9	4
	Total	242	100
Automobile Ownership	Own	102	42
	Not own	140	58
	Total	242	100
Trip Purpose	Business	61	25
	Vacation	128	53
	Education	38	16
	Other	15	6
	Total	242	100
Trip Cost Payer	Passenger	168	69
	Company	32	13
	Travel Miles	5	2
	Other	37	15
	Total	242	100

Effects of demographics on mode choice can be observed in Table 3. The modes were grouped into two categories; automobile and taxi as the comfortable modes and public transit with shuttle as the less comfortable modes. Female passengers preferred the automobile or taxi and avoided public transit and shuttle more than male passengers did. On the other hand, automobile owners preferred the comfort while non-owners preferred the public transportation. Education level affected the mode choice in an interesting way. Primary school, master and Ph.D. graduates tended to prefer the comfortable modes; while the high school and university graduates' preferences were balanced. Passengers who were traveling for vacation and education purposes have chosen the public transportation more than automobile or taxi; but majority of the business passengers preferred the comfortable transportation options. Finally, passengers whose trip cost paid by the companies they are working for preferred the comfortable modes.

Table 3. Distribution of the passenger demographics over the egress modes from SAW.

		Mode			
		Automobile+Taxi		Public Transit+Shuttle	
		Count	%	Count	%
Gender	Male	64	45.7	76	54.3
	Female	61	59.8	41	40.2
Automobile Ownership	Own	68	66.7	34	33.3
	Not own	57	40.7	83	59.3
Education	Primary School	5	71.4	2	28.6
	High School	20	48.8	21	51.2
	Undergraduate	74	49.0	77	51.0
	Master	20	58.8	14	41.2
	Ph.D.	6	66.7	3	33.3
Trip Purpose	Business	48	78.7	13	21.3
	Vacation	59	46.1	69	53.9
	Education	12	31.6	26	68.4
	Other	6	40.0	9	60.0
Trip Cost Payer	Passenger	79	47.0	89	53.0
	Company	22	68.8	10	32.2
	Travel Miles	2	40.0	3	60.0
	Other	22	59.5	15	40.5

Statistical tests were carried out to understand if the trip purpose or destination in Istanbul influenced the mode choice. Effect of destination in Istanbul can be explained as follows: Destination of a passenger may or may not be close to a public transit station, and this was investigated in the study. The investigation was made by determining the transit area of influence of each public transit station. Transit area of influence is defined as the circular catchment area of transit stations; and the radius of that circle for semi-rapid transit is ½ miles (APTA). In the data, destinations of the passengers were collected and their locations with respect to the transit areas of influences were implemented. Chi-squared tests were performed to understand the possible effects. Table 4 shows the results of the chi-squared tests. It can be observed from the significance values that both trip purpose and the destination in Istanbul, or access to rail lines, had affected the mode choice at 95 % level of confidence.

Table 4. Chi-squared tests.

		Value	**Significance**
Access to Rail	Pearson Chi-Square	11.788	0.001
Trip Purpose	Pearson Chi-Square	26.385	0.000

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3 Theory, Analysis and Results

3.1 Theory

A binary logit model was developed to show the mode choice mechanisms of egressing passengers. The choices are two categories in binary logit; automobile and taxi as one mode (comfortable mode) and public transit with shuttle as the other mode type.

Binary logit is a discrete choice modeling type and the simplest form of Multinomial Logit (MNL). In this modeling, as mentioned, there are two choices, and the probability of individual *i* choosing choice *m* is given by (Ben-Akiva, Lerman, 1985):

$$P_i(m) = \Pr(U_{mi} \geq U_{ni}, \forall n \in S_i) \tag{2}$$

with

$$P_i(m) + P_i(n) = 1 \tag{3}$$

in binary logit. In Eq. (2), S_i is the choice set for the individual *i*, *n* is the other choice in binary logit and U_{mi} is the utility function for choice *m* and individual *i*. U_{mi} can be expressed as:

$$U_{mi} = V_{mi} + \varepsilon_{mi} \tag{4}$$

In Eq. (4), V_{mi} and ε_{mi} are the deterministic and random components of the utility function, respectively. V_{mi} is a function of the explanatory variables and given by:

$$V_{mi} = \mathbf{\beta_i x_{mi}} \tag{5}$$

, where $\mathbf{\beta_i}$ is the matrix of the coefficients and $\mathbf{x_{mi}}$ is the explanatory variables vector. $P_i(m)$ is also given by:

$$P_i(m) = \frac{\exp(V_{mi})}{\sum_{n \in S_i} \exp(V_{ni})} \tag{6}$$

It should also be noted that each probability value should be greater than zero and smaller than 1.

3.2 Analysis and Results

Table 5 shows the output of the binary logit model. In the model, public transit and shuttle mode couple was the reference mode. Significance of the chi-squared test statistic is 0.000; hence, the model is significant. Furthermore, subjective goodness of measures of McFadden R^2 and Adjusted McFadden R^2 are 0.184 and 0.156, respectively. Thus, the model has a decent fit.

Speaking of model coefficients, travel time of passengers from SAW to destinations in Istanbul was the generic variable. It can be observed that its effect is small, -0.0001 and is only significant at 10% level of significance (0.051). Hence, it can be inferred that passengers pay little importance to travel time for mode choice. However, demographics were revealed to be important factors. They are all significant at 5% level of significance. As passenger age increases, passengers tend to choose public transit and shuttle. In data, gender was coded as “1” for female and “2” for male. Hence, from Table 5, it can be understood that male passengers tend to choose public transit options more, since the coefficient for gender is positive. In addition, if the destination in Istanbul of the passenger is located inside the transit area of influence of a transit station, then the passenger is less likely to choose auto, as the coefficient is negative. Furthermore, automobile ownership status of the passenger was coded as “1” as “owns an automobile” and “2” has “no ownership”. Thus, it can be said that if the passenger owns an automobile, he or she is more likely to choose the comfortable modes; automobile and taxi. The last factor in the model is travel cost payer. This factor is a categorical variable and can be explained as follows. There are 4 travel cost payer categories: Passengers themselves (coded as 1), company (coded as 2), travel miles (coded as 3) and other (coded as 4). Hence, from the positive coefficient of this variable, it can be inferred that if the passenger did not pay for the trip, then he or she will prefer the comfortable modes to public transit or shuttle.

Table 5. Binary logit model.

Generic Variables		**Coefficient**	**Significance**
Travel Time		-0.0001	0.051
Variables Specific to Alternatives		**Coefficient**	**Significance**
Auto and Taxi	Constant	0.667	0.499
	Age	0.036	0.023
	Gender	0.646	0.034
	Trip Purpose	-0.732	0.000
	Rail Accessibility	-0.814	0.010
	Auto Ownership	-0.776	0.019
	Travel Cost Payer	0.339	0.015
LL(c)			-167.609
LL(B)			-136.823
Chi-squared Test Statistic			61.572
Significance			0.000
McFadden R^2			0.184
Adjusted McFadden R^2			0.156
Number of Observations			242

4 Conclusions

In this research, a carsharing service between SAW and P&R location of Tavsantepe rail transit station is proposed. The reason for this was providing a mode as comfortable as but cheaper than taxi. Passengers leaving SAW will pay lower cost to access Tavsantepe station; hence rail transit from there will become more attractive. Therefore, the public transit share will increase. A binary logit model was developed.

In the binary logit model, it was observed that passengers egressing from SAW gave little importance to travel time in their mode choices. Hence, it can be concluded that even though the transit modes have the higher travel time reliability compared to taxi and automobile, passengers opted for the latter modes. Thus, it can be argued that passengers preferred comfort over travel time. Further, majority of the female passengers preferred the comfortable modes, and being female increases the likelihood to choose the comfortable modes over the transit. So, we conclude that the proposed carsharing service to Tavsantepe station will both enable the comfortable travel and increase the public transit ridership.

Policy-wise, there are several suggestions. Passengers who use the proposed carsharing service may get discount fares on their transit trips between Tavsantepe and their destination in Istanbul. Further, since also the passengers who are departing can also use this service from Tavsantepe to SAW, relevant flight information can be provided at both Tavsantepe station and P&R facility. In future studies, transferability of the model and proposed service to the other cities and airports can be discussed.

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