

MODELLING OF GROUND ACCESS MODE CHOICE: EMPIRICAL EVIDENCE FROM MEHRABAD INTERNATIONAL AIRPORT, TEHRAN, IRAN

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Abstract

The aim of this study is to investigate air travellers' behaviour with regard to choices for ground access to this airport. Questionnaire data were collected from 684 respondents. Multinomial logit modelling was employed for this purpose. These findings indicate that in families with at least one car of their own, the tendency for using bus and carpooling was decreased. In addition, it was found that those in the 36 - 40 age group were more inclined to take the taxi. Finally, the results of this study suggest that with the growing price of the private car, the tendency to use it was diminished. Therefore, if transportation authorities seek to reduce the use of personal cars, it is possible to make the use of private cars expensive with increasing the parking cost in the airport. This may lead to the reduction of using private cars in land access to Mehrabad airport

Keywords:

Mehrabad airport;
Multinomial Logit;
Carpooling;
Stated preference;
Spss.

1 Introduction

Mehrabad International Airport (MIA) in Tehran, Iran, is opened in 1938 as the first airport of Tehran in both international and domestic flights. After 2007, Imam Khomeini International Airport (IKIA) was chosen to serve international flights of MIA airport. MIA was the busiest airport in Iran, handled 16,678,351 passengers in 2016 (20 % increase compared to 2015). Exploring the travellers' behaviour and important factors for ground access mode choice (bus, taxi, subway, private car, etc.) to MIA can be useful for transportation and airport planners. Because of easier accessibility of data and the high number of passengers, we chose Mehrabad International Airport in preference to other airports.

The relationship between air transport and economic growth is very important [1, 2]. In recent years, there have been many studies about the choice of ground access to the airport. One can mention [3] and [4] as the pioneers in this area of research. Trip time and trip cost have been found to be the most important parameters determining the choice of trip by those travelling in air. [5] showed that for those travelling for a purpose other than business, the cost of access is important while for those travelling for business, especially in long flights, the time of access to the airport is of great importance. Among the other studies and parameters identified as important in the choice of travellers, it can be mentioned [6-9] for the purpose of the trip. Also [10, 11] for socio-demographic features of travellers (the number of accompanies, amount of cargo, income, gender, age, education, etc.) and [12] for the time they have to wait in the vehicle and out of it.

One of the methods used for the collection of data in this area is the preference expressed. [9, 11, 13, 14] focused on a new way travellers chose based on the choice of trip they had in their minds. Also in most studies due to convenience, high income, car ownership per capita and in some cases, lack of an efficient public transportation system, the use of taxi and private car has been the most common choice [15 - 17]. For example, [18] used social psychological approaches to reduce private car trips to Manchester airport, in United Kingdom. In addition, [19] modelled taxi drivers' decision for ground access to John F. Kennedy (JFK) airport. In Hong Kong, due to the far distance between city centre and airport (therefor, the high cost of taxi and personal car) the contribution of this sector (bus,

AE) has been 71 % [20]. Nowadays, the policy in many countries is enhancing public transportation and reducing the use of personal cars. There have been some studies investigating the behaviour of the elderly with particular problems [21, 22].

In [23] was investigated the travellers' behaviour in accessing Imam Khomeini International Airport (IKIA), using 2649 sample. Access mode choice is affected by gender, monthly income, vehicle ownership, trip purpose and peak travel time. The Binary Logit model results indicated that socio-economic characteristic more significantly affect access mode choice for non-business travel than for business travel. Also, business traveller tend to pay more to use private modes to access IKIA. Choo, S. et al [24] used travel characteristic and sociodemographic in modelling the access mode choice to Daegu Airport and Gimpo Airport, in Korea. Trip purpose, travel time, travel distance, gender, age, income and occupation are the most important variables that effect mode choice significantly. In addition, the findings showed that demographic characteristic more significantly affect access mode choice for non-business travel than for business travel. Gokasar, I. et al [25] analysed the ground access mode choice for Ataturk International Airport (IST) using Multinomial Logit. The results revealed that trip distance, trip cost, type of destination, time difference between flight time and departure time, employment status, automobile ownership status and location of the trip origin are significant variables. The trip origin to airport is an important factor for choosing access mode.

Under current conditions, access to Mehrabad airport is possible through bus (only one line going to Tehran downtown), taxi, private car (car parked in airport parking until returning from trip), and private car got off (taking passengers to the airport by relatives without parking the car in the airport parking). Furthermore, the use of sub-way and carpooling was investigated using the preference expression method. Based on the mentioned, this study aimed at investigating air travellers' behaviour with regard to choices for ground access to Mehrabad International Airport. The choices included subway, bus, carpooling, taxi, private car (parking) and private car (car drop-off). In this study, important factors affecting air travellers' choice for ground access to Mehrabad International Airport were investigated for the purpose of better planning and services in the transportation system. This research is organized as a follows. In the second section, research methodology is briefly introduced and in the third and fourth sections, data collection and analysis are discussed, respectively. Finally, sections five and six present modelling and the results obtained.

2 Methodology

We use Multinomial Logit as our method of analysis. In logit models, the decision maker n has j alternatives, the utility gained by the person that is obtained from alternative j , has two parts: a) a part which is shown as V_{nj} and is visible by researchers as the parameters affecting the behaviour of decision-maker; b) the unknown and unobservable part, which is shown as ε_{nj} , and researcher considers it randomly.

If selection is done among some choices, it is possible to obtain the probability of the selection of each choice using this model. In addition, desirability function has been brought here.

$$P_A = \frac{\exp(U_A)}{\sum_j \exp(U_j)}, \quad (1)$$

where:

P_A = the probability of selecting choice A ,

U_A = desirability function for the selection of choice A ,

U_j = desirability function for the selection of choice j .

It should be note that ratio of the probability of selecting two choices is only dependent on the desirability function of these two choices and independent of the desirability of other choices. It should be mentioned that the overall of structure of logit in the case of two choices is called double and multiple in the case of several choices [26].

After designing questionnaire with Xlstat software and collecting data through the use of sequence method, in the form of n , passengers travelling to the airport, the supreme model was introduced (with Nlogit4 software) and the validity of the data was reported.

3 Data collection

The questionnaire included 18 questions about personal features of passengers, trip features of the passengers, and the choice of land access to the airport based on the features of the related question. Like similar studies done in other countries, this study focused on passengers leaving Mehrabad Airport.

To design the questionnaire, Xlstat software was used. Seven designs were made through this software and for the three variables of trip time, trip cost, and facilities, three different values were assumed and then the optimal states were designed. After that, the questionnaire was prepared. According to the prediction that passengers were not aware of carpooling system as shown by preference expression, a graphic figure showing the 8 stages (from registering carpooling to getting on), for the purpose of using carpooling at the end of each questionnaire was drawn. After preparing the questionnaires according to the timetable, about 700 questionnaires were administered during five days in summer, 2018. This was done using the sequence method quite randomly and in the form of face-to-face interview (all of the questions were asked and some necessary information or explanations were expressed by interviewer, then respondents answered them one by one) and preference expression among passengers leaving Mehrabad airport. After questioning the passengers and eliminating some questionnaires not filled completely, 684 questionnaires were analysed and from this, about 10 % questionnaires (68) were kept apart and used for validation at the end.

The collected data were analysed by Spss software. Following the results of analysis of some of the variables that were used in the final model is shown. Table 1 shows socio-demographic characteristics of respondents in this study. According to descriptive analysis, 33 % of the passengers travelled by themselves (unaccompanied), 24 % travelled with one accompany and 13 % travelled with two accompanies (30 % of them travelled with more than two accompanies). In terms of travel purpose, 40 % of the passengers travelled for business. This was unlike the other airport in Tehran (Imam Khomeini International Airport), where most passengers travelled for non-business purposes. 37 % of the respondents travelled for non-business and 23 % of them travelled for education, remedial and other purposes. In terms of passenger baggage, 40 % of respondents have bag. 43 % of them have one suitcase, 11 % have two suitcases and 6 % have more than two suitcases.

Table 1: Socio-demographic characteristics of respondents.

	Frequency/Mean	Percentage
Gender (n=671)		
Male	464	69.1
Female	207	30.9
Marital Status (n=667)		
Single	202	30.3
Married	465	69.7
Monthly Income (n=369)		
Less than 1 million Tomans(TN) ¹	39	10.6
1 to 2 million Tomans	178	48.2
2.1 to 4 million Tomans	88	23.9
More than 4 million Tomans	64	17.3
Educational level (n=623)		
Under diploma	23	3.7
Diploma	107	17.2
Associate degree	39	6.3
Bachelor's degree	260	41.7
Master's degree	137	22
Ph.D.	57	9.1
Car Ownership (n=674)		
No car	107	15.9
1 car	375	55.6
2 cars	142	21
More than 2 cars	50	7.5
The number of members under 18 years in household (n=568)		
No member	292	51.4
1 member	166	29.2
2 members	86	15.1
3 members	17	3
More than 3 members	7	1.3
Age	35	

¹The Toman (TN) is a super unit of the official currency, Rial (IRR), 1TN= 10IRR; 3200 TN = 1USD (\$).

Questions 16 and 17 in the questionnaire were related to the choice of ground access to Mehrabad Airport for business or non-business purposes and according to the variables cost (Toman), time (minute) and facilities. Table 2 shows the comparison of the choice of access for business or non-business purposes. It can be observed that the biggest contribution, in the order mentioned, was from taxi and sub-way and the contribution of personal car was around 20 %, showing the good welcome by the passengers. It can also be seen that people travelling for business preferred to park their cars in airport parking while those travelling for non-business purposes preferred to use a car and got it off.

Table 2: The distribution of purpose of the travel passengers (respondents).

Mode	With business purpose (%)	With non-business purpose (%)
Sub-way	20.7	20.4
Bus	3.4	2.8
Carpooling	5.8	5.9
Taxi	46.6	46.1
Private car (Parking)	12.1	11
Private car (Car drop-off)	7.9	10.3
Sum	96.4	96.4
Valid	3.6	3.6
Total	100	100

4 Modelling

4.1 Structure of multinomial logit model

For an investigation in to the choice of ground access to Mehrabad airport using multinomial logit modelling, the following structure is used, Fig. 1:

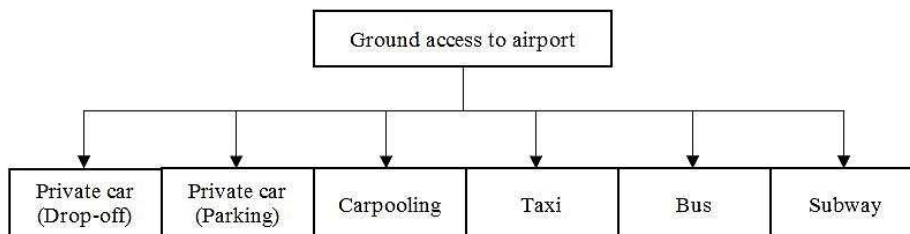


Fig. 1: Structure of Multinomial Logit Model used for this study.

Fig. 1 displays the structure of logit model used in this study. It can be seen that passengers can choose among six different ways to come to Mehrabad Airport. Under current conditions, passengers can take taxi, use their own personal cars (parking in the airport) and get off other people’s cars. However, in this study, through preference expression, three other ways, sub-way, bus, and carpooling, were also considered. After investigating the correlation between the variables using Spss and eliminating variables with high correlation, the variables used in modelling had an acceptable correlation. In the model, the maximum correlation was between the cargo amount and gender, being about 0.284. The model presented is as shown in Fig. 1, with six states. The variables used in the model were as follows in Table 3:

Table 3: The variables used ground access to airport multinomial logit model.

Variable in the model	Type variable	Describe and how the coding
ONE	Dummy	Constant
D-DTRIP	Dummy	Number of domestic flights the passengers had during the past 5 years (equal = 1, otherwise = 0)
D-AGE2	Dummy	The Age group 26-30 years (equal=1, otherwise=0)
D-AGE4	Dummy	The Age group 36-40 years (equal=1, otherwise=0)
D-AGE5	Dummy	The Age group 41-50 years (equal=1, otherwise=0)
Gender	Dummy	Gender (male=0, female=1)

O-LESS	Ordinal	Number of household members over 18 years
D-VEH	Dummy	The car ownership (without car=0, with car=1)
D-DEG1	Dummy	Education under diploma and diploma (equal=1, otherwise=0)
O-ENT	Ordinal	Number of accompanies
D-SA1	Dummy	Monthly Income, Less than 1 Million Toman (equal=1, otherwise=0)
D-SA3	Dummy	Monthly Income, 4 Million Toman or more (equal=1, otherwise=0)
D-CARGO	Dummy	Baggage (bag=0, more than one suitcase=1)
DD-CITY	Dummy	The traveling origin (others areas and cities=0, Surrounding areas of Mehrabad airport (including areas 2,5,9,10,17,18,21,22) =1)
R-COST	Ratio	Trip cost (Toman)
D-PUR	Dummy	The purpose of the trip (work=0, non-work=1)

After considering and analyzing more than 200 models using Nlogit4 software, 70 different variables including the major variables and some variables subjected to mathematical calculation were recognized. These included the square root of trip time, the square root of trip cost, the square root of income, the logarithm of trip time, the logarithm of trip cost, the logarithm of income, income divided by trip cost, the logarithm of income divided by trip cost, etc. The cause-effect relationship and correlation control and meaningful relations between variables were considered in different models and with the addition of other variables; finally, 15 variables with the meaningfulness of more than 90 % were applied in the ultimate model. The results of the ultimate model have been brought in Table 4.

Table 4: Results of an investigation in to the choice of ground access to airport using multinomial logit modelling.

Variable	Coefficient	Standard error	b/St.Er	P[Z]>z
ONE1	1.116***	0.251	4.441	0.0000
ONE2	0.942*	0.568	1.658	0.0972
ONE3	0.231	0.493	0.47	0.6387
ONE4	0.577	0.352	1.638	0.1014
ONE5	0.522	0.601	0.868	0.3582
D-DTRIP4	0.722**	0.317	2.278	0.0227
D-AGE25	0.954***	0.34	2.802	0.0051
D-AGE44	0.974***	0.304	3.203	0.0014
D-AGE51	-0.717**	0.327	-2.196	0.0281
Gender3	1.363***	0.434	3.138	0.0017
O-LESS4	-0.229*	0.125	-1.831	0.0671
D-VEH2	-2.301***	0.648	-3.553	0.0004
D-VEH3	-1.543***	0.503	-3.064	0.0022
D-DEG11	1.011***	0.333	3.038	0.0024
O-ENT4	0.143*	0.078	1.829	0.0674
O-ENT5	0.279***	0.099	2.81	0.0049
D-SA11	-0.723**	0.331	-2.181	0.0292
D-SA33	1.38***	0.466	2.958	0.0031
D-CARGO1	-0.479*	0.262	-1.829	0.0674
DD-CITY1	1.075**	0.424	2.537	0.0112
DD-CITY4	1.096***	0.371	2.957	0.0031
R-COST5	-0.848D-04*	0.445D-04	-1.904	0.0569
D-PUR2	-1.207*	0.702	-1.719	0.0855

Note: ***, **, *: significance at 1 %, 5 %, 10 % level.

$$\rho_c^2 = 1 - \frac{LL(\beta)}{LL(c)} = 0.0739 , \tag{2}$$

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(0)} = 0.0843 , \tag{3}$$

where:

the log-likelihood function for zero coefficients: $LL(0) = -601.078$,

the log-likelihood function grape seed fixed parameters: $LL(c) = -594.337$,

the log-likelihood function for the estimated coefficients: $LL(\beta) = -550.4154$.

4.2 Validation of data

For the validation of data, from 684 questionnaires, 68 (10 %) were kept apart and validated. The values of variables for 68 samples were separated and analysed in desirability function obtained from the model for each of the options (sub-way, bus, carpooling, taxi, private car (parking in the airport, and other people’s cars (getting off the car and not parking in the airport). Then, by using equation (1), and putting the values of desirability function in it, the probability of each choice was estimated. After that, the largest probability was taken as the selection of the model. Finally, validation was done according to Table 5.

Table 5: The validation of data of an investigation in to the choice of ground access to airport using multinomial logit modelling.

Mode	Percent of sampling	Percent of selection of the model	Percent of sampling with model
Sub-way	23	8	4
Bus	0	0	0
Carpooling	2	0	0
Taxi	48	86	46
Private car (Parking)	17	6	0
Private car (Car drop-off)	10	0	0
Total			50

5 Discussion and interpretation of results

In this model the value of ρ^2 is 0.0843. The fixed figure in the model indicates the average of the effect of variables not seen in the model. Table 6 shows a brief interpretation of variables used in the model that had some meaningfulness more than 90 %.

Table 6: Significant variables in multinomial logit model.

Interpretation	Significant grade	Significant amount	Mode	The most correlation with	The least correlation with	Significant variable
1. Passengers who had experienced 3 domestic flights or more were more likely to use taxi.	95 %	2.278	Taxi	The age group 26-30years (-0.204)	Trip cost (-0.009)	Domestic flights
2. People within 26-30 age group preferred to use private car (parking).	99 %	2.802	Private car (Parking)	The age group 41-50years (-0.259)	Gender (-0.001)	The age group 26-30 years
3. People within 36-40 age group preferred to use taxi.	99 %	3.203	Taxi	The age group 26-30years (-0.229)	Trip cost (-0.004)	The age group 36-40 years
4. People within 41-50 age group were less inclined to use subway.	95 %	-2.196	Subway	The age group 26-30years (-0.259)	Trip cost (-0.01)	The age group 41-50 years
5. Women were more interested in carpooling.	99 %	3.138	Carpooling	Baggage (0.284)	The age group 26-30 years (-0.001)	Gender
6. With the increase in the number of passengers who were over than 18 in their families, the preference for taking the taxi was decreased.	90 %	-1.831	Taxi	The age group 41-50 years (0.254)	Trip cost (0.003)	Number of household members over 18 years

7. Families with at least one car of their own, the tendency for using bus and carpooling was decreased.	99 % 99 %	-3.553 -3.064	Bus Carpooling	Degree under diploma and diploma (-0.15)	Trip cost (-0.007)	The car ownership
8. People with degrees lower than diploma and diploma itself preferred to use sub-way.	99 %	3.038	Subway	Income, less than 1000000 (0.215)	Gender (-0.005)	Degree under diploma and diploma
9. With the increase in the number of those accompanies passengers, the tendency for taking the taxi and using the private car was increased.	90 % 99 %	1.829 2.81	Taxi Private car (Parking)	Baggage (0.222)	The traveling origin (0.004)	The number of those accompanies
10. Those with an income of less than 1 million tomans, there was less tendency to use subway.	95 %	-2.181	Subway	Income, 4000000 Toman or more (-0.28)	Trip cost (0.00)	Income, less than 1000000 Toman
11. Those with an income of more than 4 million tomans preferred to carpool.	99 %	2.958	Carpooling	Income, 4000000 Toman or more (-0.28)	Trip cost (-0.003)	Income, 4000000 Toman or more
12. Passengers who had at least one baggage were not so inclined to take the subway.	90 %	-1.829	Subway	Gender (0.284)	The traveling origin (-0.002)	Baggage
13. Passengers who had come from zones near the airport had a more marked tendency to take the subway and taxi.	95 % 99 %	2.537 2.957	Subway Taxi	Income, 4000000 Toman or more (-0.096)	Baggage (-0.002)	The traveling origin
14. With the growing price of the private car, the tendency to use it was diminished.	90 %	-1.904	Private car (Parking)	The number of those accompanies (0.021)	Income, less than 1000000 toman (0.00)	Trip cost (Toman)
15. Passengers not travelling for business were less inclined to take the bus.	90 %	-1.719	Bus	The traveling origin (0.05)	Trip cost (0.00)	The purpose of the trip

The results showed that passengers who had three flights and those with the most flights in the country (more experienced passengers) in the last 5 years had a more marked tendency to take the taxi. It may be because they have enough experience, they know which mode is better. With regard to the age of the passengers, the results showed that people within 26 - 30 and 36 - 40 age groups preferred to use their private car (parking) and take the taxi, respectively. It is expected because younger people like to drive themselves more than take the taxi. People within 41 - 50 age group were less inclined to use sub-way. The meaningful relation for the gender of passengers showed that women were more interested in carpooling. This is probably because of the characteristic and personality of women. With the increase in the number of passengers who were over than 18 in their families, the preference for taking the taxi was decreased. With regard to education, it was found that passengers with degrees lower than diploma and diploma itself preferred to use sub-way. These persons may pay more attention to the costs of travel to the airport. As expected according to the previous studies, two factors, income and car ownership, showed that in families with at least one car of their own, the tendency for using bus and carpooling was decreased. It is expected, may be because of easier access to the airport. For passengers with an income of less than 1.5 million Tomans, there was less tendency to use sub-way, and passengers with an income of more than 4 million Tomans preferred to carpool [4, 9 - 11, 16]. With the increase in the number of those accompanies passengers, the tendency for taking the taxi and using the private car was increased. May be, carrying of the baggage and accessing the airport is easier this way. Cargo, as shown in the previous studies, was found to be one of the determining parameters, showing that passengers with more cargo were more interested in taking the taxi and using their private cars [4, 5, 16]. It was also found that passengers who had at least one baggage were not so inclined to take the subway. Passengers who had come from municipality zones near the airport (2, 5, 9, 10, 17, 18, 21 and 22) had a more marked tendency to take the subway and taxi. As expected, with regard to trip cost, it was shown that with the growing price of the private car, the tendency to use it was diminished. Finally, for the variable of trip purpose, it was shown that those passengers not travelling for business were less inclined to take the bus. In this model and other models employed in this stage, car ownership, the 36-40 age group, and gender were found to be the influential parameters.

6 Conclusion

The study reported in this paper has sought to investigate air travellers' behaviour with regard to choices for ground access (private car-parking, private car-car drop off, bus, subway, carpooling and taxi) to Mehrabad International Airport, which is located in Tehran, Iran. Data collection for this study was done during five days in summer, 2018. We used Multinomial logit model with Nlogit4 software. The survey was conducted in Mehrabad International Airport and administered as a face-to-face interview. A total number of 684 questionnaires were collected, with the degree of validation being 50 %.

In this study, important factors affecting air travellers' choice for ground access to Mehrabad international airport were investigated for the purpose of better planning and services in the transportation system. The results of this study showed the importance of the car ownership variable. These findings indicate that in families with at least one car of their own, the tendency for using bus and carpooling was decreased. Then, with the increase in the number of private cars in recent years in Iran (according to 2012 statistics, 200 cars for 1000 persons, showing a growth twice more than 8 years ago), it is expected that in the near future, we would witness a reduction in the use of public transportation (bus and carpooling). The meaningful relation for the gender of passengers showed that women were more interested in carpooling. The other variable was the number of accompanying passengers, showing that with the increase in their number, the tendency to take the taxi and use the private car was increased. This could be due to the more economical cost of the trip and more convenience of the passengers. In addition, cargo was found to be an important variable in the choice of passengers, that passengers who had at least one baggage were not so inclined to take the subway. This can be to some extent tackled by devoting a special place for cargo in subway wagons so that they can be transferred to airport terminal. The meaningful relation for the gender of passengers showed that women were more interested in carpooling. Also, it was found that those in the 36 - 40 age group were more inclined to take the taxi. Finally, we found that with the growing price of the private car, the tendency to use it was diminished. Therefore, if transportation authorities seek to reduce the use of personal cars, it is possible to make the use of private cars expensive with increasing the parking cost in the airport. This may lead to the reduction of using private cars in land access to Mehrabad airport.

For future studies, the following cases are suggested:

- a) The study of the behaviour of aged passengers (65 and above), due to limitations involved, in comparison to other age groups, and identification of problems and solutions for improving the condition of this age group.
- b) The case study on Specific groups of air travellers, including females, various nationalities, tourist travellers, business travellers, work travellers, leisure travellers, pilgrimage travellers.
- c) Study of the staffs Ground Access to Airport.
- d) The use models, such as: Mixed Multinomial Logit Model and Cross Nested Logit.

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